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WASTEWATER CHARACTERIZATION FOR THE SPECIALTY FOOD INDUSTRY

American Frozen Food Institute

PREPARED FOR
Pacific Northwest Environmental Research Laboratory

December 1974

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Related production and processing information was used to calculate the wastewater generation per 1,000 kilograms of production in terms of: 5 day Biochemical Oxygen Demand, Chemical Oxygen Demand, Suspended Solids, Volatile Suspended Solids, Total Phosphorus, Total Kjeldahl Nitrogen, and Grease and Oil.

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ABSTRACT

The specialty food industry generally falls within SIC Codes 2032, 2035 and 2037 and includes approximately 2,300 plants in the United States which produce a wide variety of food products. For waste categorization purposes the specialty food industry was divided into ten categories on the basis of ingredients used, type of product, and liquid waste generation. Twenty-six nationally distributed specialty food plants were investigated and 24 of these field sampled for ten days each to determine raw wastewater characteristics and volume.

Related production and processing information was used to calculate the wastewater generation per 1,000 kilograms of production in terms of: 5 day Biochemical Oxygen Demand, Chemical Oxygen Demand, Suspended Solids, Volatile Suspended Solids, Total Phosphorus, Total Kjeldahl Nitrogen, and Grease and Oil.

From one to six plants were covered in each specialty food category. The categories showed wide variations in waste generation between each other, and in some cases between plants within a category. The results will be helpful to all specialty food plants in gauging their waste generation against other plants in their category. In addition, the data will assist prediction of waste loads from new plants and will aid regulatory agencies in establishing wastewater discharge standards.

This report was submitted in fulfillment of Grant No. R-801684, by SCS Engineers, under sponsorship of the Environmental Protection Agency and the American Frozen Food Institute. Work was completed as of September 1973.

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Laboratory Director: Walter Rose, National Canners Association, Berkeley, California.

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We are especially grateful to the 26 specialty food plants which participated in this project. Each volunteered substantial personnel time during the field studies without any compensation. We sincerely hope this report about waste generation from the specialty food industry justifies their unselfish contributions.

SECTION I

CONCLUSIONS

- The canned and frozen specialty food industry includes approximately 2,300 individual plants in the United States. The greatest numbers are concentrated near the large population centers, however, many of larger individual plants are located in rural areas.

- Categorization of the specialty food industry is extremely difficult because of the wide spectrum of different products produced and the many other differences between individual plants such as size, percent of maximum production capacity utilized, etc. A preliminary division into ten categories is suggested by this study, largely on the basis of type of product.

- Raw liquid waste loads generated by individual plants within the specialty food industry vary greatly but in general were found to be higher than was anticipated by the investigating team. Average five day Biochemical Oxygen Demand (BOD) generation ranged from 5 to 25 kilograms per 1,000 kilograms (kg/kkg) (10 to 50 lbs/ton) of production, Suspended Solids (SS) generation from 1 to 26 kg/kkg (2 to 52 lbs/ton) of production, and there were similarly wide ranges for other waste constituents. Average wastewater strengths in terms of BOD ranged from 300 to 3,200 milagrams per liter (mg/l), and in terms of SS from 200 to 3,700 mg/l. Generally Chemical Oxygen Demand (COD) values averaged about 200 percent of the BOD values. Grease and oil concentrations ranged from zero upward to a high of 2,000 mg/l.

- The wide differences (more than 10:1) in raw waste strength between categories of the specialty food industry are due to the following major factors:

  - Richness of product ingredients.

  - Number and type of unit processes utilized during production.

  - Number of different products and frequency of changes in product.

  - Extent of ingredient preprocessing which has occurred elsewhere.

  - Moisture content of ingredients and final product.

  - Management desire to reduce waste generation.

  - Other factors, including plant size, number of shifts, percentage of maximum production capacity in use, cost of water supply and waste disposal, and economic ability of the plant to modernize equipment.

- Of the 26 specialty food plants investigated, 21 discharge into municipal systems. The characteristics of the raw wastes and the reported performance of existing treatment facilities indicate that specialty food industry wastes are satisfactory for combined treatment in municipal treatment plants. Pretreatment prior to municipal discharge ranged from no treatment up to activated sludge. Complete treatment prior to direct discharge was practiced at five plants and was reported to achieve high levels of pollution reduction. Treatment costs, where reported, were also high due to the high raw waste strengths.

SECTION II

RECOMMENDATIONS

1. The results of this study should be given wide dissemination in the specialty food industry with the objectives of:

   (a) Obtaining opinions from knowledgeable individuals as to the validity of the industry characterization suggested by this study.

   (b) Obtaining additional effluent characterization data applicable to the various industry categories. The American Frozen Food Institute (AFFI) could serve as clearing house for (a) and (b).

   (c) Causing individual plants to compare their waste generation with similar plants described in this study. Those plants which feel their waste generation is excessive should look to in-plant programs to reduce waste discharged to the sewer.

2. In order to achieve wide dissemination, it is suggested that the following be considered:

   (a) Printing of the report by the government printing office as soon as possible, with concurrent notification by AFFI and National Canners Association (NCA) to their membership that the report is available through the National Technical Information Service or Government Printing Office.

   (b) Printing of the report by AFFI and/or NCA for distribution.

   (c) The scheduling of well-publicized technology transfer seminars in several locations. The seminars would use this report and other manuals as a basis for assisting industry personnel in assessing and reducing wastewater discharges. It is apparent that plants which undertake a comprehensive program of in-plant education and process modification are able to achieve remarkable reductions in liquid waste generation.

3. In preparation for industry-wide effluent guidelines which will probably be promulgated by the United States Environmental Protection Agency (EPA) in late 1974, the industry should immediately begin expanding upon the data base developed in this "broad brush" report. In order to develop realistic and equitable guidelines more reliable data is required to describe the industry, characterize its wastes, evaluate various treatment methods, and provide confirmable economic data showing the economic impact of increasing degrees of pollution control upon various plants in the industry. A series of case studies is suggested as the best method to accomplish this recommendation. Initial case studies should be made at specialty food plants which are presently achieving exemplary results in reducing in-plant pollution generation and/or end-of-the-pipe waste-water treatment. The methods used and costs incurred by these exemplary plants (three plants investigated for this study report Biochemical Oxygen Demand (BOD) reduction in the 90 percent range) should be accurately determined. Following these initial case studies, a second series of case studies should be made with the objective of determining the technical feasibility and economic impact of applying similar pollution reduction requirements upon other typical plants in the industry. Emphasis should be upon plants of various size production capacity, the availability of land for treatment and disposal, and the economic resources of the plant.

SECTION III

INTRODUCTION

Specialty foods, as used in this project, includes frozen and canned items containing several major ingredients. Included are such varied products as frozen dinners, frozen and canned pre-cooked fish, beef, and poultry dishes, frozen and canned stews and soups, frozen or canned ethnic/nationality foods, frozen vegetables in sauce, frozen bakery products and other prepared and/or pre-cooked foods. Specialty food firms generally fall within SIC Codes 2032, 2035 and 2037.

The magnitude of this segment of the food industry is made obvious by a stroll through any supermarket: more shelf and freezer space is taken by specialty foods than by ordinary canned and frozen fruit and vegetable items. Exact production data on a national scale is lacking. However, combined statistical sources estimate that specialty foods production exceeds other types of food production.

Section VI of this report contains a tabulation of specialty food plant distribution by type and state. A total of 2,321 specialty food plants are shown, with the largest number in the states of California, New York, Illinois and Pennsylvania. Meat specialties has the largest number of individual plants among the categories.

During the second half of 1973 AFFI conducted a study to characterize wastewater generation by the specialty food industry. AFFI was aided by NCA, which performed all laboratory analyses, and SCS Engineers, which performed all field work and prepared the final report. Financial assistance was provided by EPA under Grant No. R-801684.

The major objectives of the project were to:

- Inventory and categorize the specialty foods industry.

- Investigate typical raw waste loads generated by major categories of the specialty foods industry.

This information is needed by AFFI, NCA and EPA to increase their background knowledge in answering questions concerning waste generated by the specialty food industry and to regulate industry waste generation in an equitable manner. Categorization proved difficult because of product diversity, but the industry was eventually divided into ten categories on the basis of ingredients used, type of product, and liquid waste generation.

The final ten categories are:

1. prepared dinners
2. frozen bakery products
3. dressings, sauces and spreads
4. meat specialties
5. canned soups and baby foods
6. tomato-cheese-starch combinations (Italian specialties)
7. sauced vegetables
8. sweet syrups, jams and jellies
9. Chinese and Mexican foods
10. breaded frozen products

Section V describes in detail the categories and the rationale for their selection.

To achieve the second project objective, i.e., preliminary characterization of raw wastewater loads generated by plants within each category, an effluent sampling program was initiated. Data was obtained from field investigations of 24 specialty food plants and historical study of 2 others, located throughout the United States. Field investigation generally consisted of daily time-interval composite sampling of raw wastewater for 10 consecutive operating days supplemented by the gathering of related wastewater volume, plant production, and basic processing information. Individual case studies of these plants are found in Appendix A and provide wastewater concentrations, volumes generated, productivity factors, products, ingredients and wastewater generating operations. Simplified process flow diagrams accompany the studies where obtained.

Field determination was made of pH, temperature, volume (existing records and metering devices) and any unusual visual characteristics of the waste. Laboratory analysis included chemical oxygen demand (COD),5-day biochemical oxygen demand (BOD), suspended solids (SS), volatile suspended solids (VSS), total kjeldahl nitrogen (TKN) as mg/l N, total phosphorus (TP), and oil and grease.

Results of the wastewater characterization effort are presented and analyzed in Section V. Table 1 on the following page, provides a summary of BOD and SS concentrations and weight per unit of production, as well as average wastewater generation figures for all the categories.

Final treatment or pre-treatment of the wastes from the specialty food industry was not within the scope of this project, per se. The field team did, however, note treatment practices at the individual plants investigated. Their observations are described in Section VI. The majority of plants utilized gravity settling and flotation prior to discharge to a municipal sewer. Several of the large plants, however, maintain extensive biological or physical-chemical facilities including one or more combinations of the following processes: aerobic and anaerobic lagoons, activated sludge, trickling filters, coagulation/floculation, aeration, and land disposal.

This study is the initial attempt to characterize the wastes generated by a major segment of the nations food processing industry. The results will be helpful to all specialty food plants in gauging their waste generation against other plants in their category. In addition, the data presented will assist prediction of waste loads from future new plants and will aid regulating agencies in establishing wastewater discharge standards. Finally, this initial venture points the way for future work in several areas of importance as described in the recommendation's section of the report.

Table 1. AVERAGE POLLUTANT CONCENTRATIONS, WEIGHTS PER UNIT PRODUCTION,(1) AND WASTEWATER GENERATION BY CATEGORY

Category	BOD		SS		
	Ave. conc. (mg/l)	Wt. per unit production (kg/kkg)	Ave. conc. (mg/l)	Wt. per unit production (kg/kkg)	Wastewater volume per unit production (l/kkg)
1	1,900	17	1,500	14	12,000
2	3,200	23	2,200	14	11,000
3	2,600	7.5	1,200	3.5	2,800
4	820	9.5	460	6.1	10,000
5	560	12	320	7.6	22,000
6	370	7.2	220	6.0	29,000
7	310	25	250	21	85,000
8	2,400	5.1	400	1.0	2,400
9	570	6.9	200	2.8	14,000
10	2,400	26	3,700	26	48,000

(1) See next page for explanation of production weights.

(1) In this study the investigators were faced with some category situations where production data was available only in terms of finished product and in other cases where production data was available in terms of raw product. Waste loads for the following categories are stated in terms of finished production tons: 1, 2, 3, 4, 7, 8, and 9; and waste loads for categories 5 and 10 are stated in terms of raw product tons. In the case of category 6, plant R is stated in terms of raw product tons and plants O, P, and Q in terms of finished product tons.

Since the majority of specialty food plants are largely reprocessors of food pre-processed elsewhere there often is little difference between raw product tonnage and finished product tonnage. Below, an estimate is provided of the percentage of finished product weight to raw product weight by category:

Category	$\frac{\text{Finished Product wt}}{\text{raw product wt}} \times 100$	Comment
1	95	wtr added
2	100	wtr added
3	100	wtr added
4	90-100	fat trim
5	70-110	variable product
6 (frozen)	100	
6 (canned)	130	much wtr added
7	40-90	variable product
8	100-150	wtr added
9	80-100	dependent on vegetables processed
10	100	

SECTION IV

SAMPLING AND ANALYTICAL PROGRAM

This section of the report describes the approach used in selecting specialty food plants to be investigated, performing the field investigation programs, and categorizing the industry according to the results received.

PLANT SELECTION

A preliminary assessment of the types, number and locations of specialty food plants was prepared, and a tentative determination made of representative plants in the west, midwest, and east which appeared to be desirable candidates for field investigation. Each candidate plant was contacted by phone and letter, given a description of the project, and requested to indicate a preliminary assurance of cooperation. A series of meetings were arranged by AFFI in San Francisco, Chicago, and Washington, D.C. at which the project technical team met with company representatives to work out details of individual plant investigations. Every attempt was made to insure that the participating industry plants were cognizant of their responsibilities to the project. The final selection of participating plants was made to provide diversity in type of product and geographical area. The plants were located as follows:

East - 6 plants

Midwest - 9 plants

West - 11 plants

FIELD INVESTIGATION

During the field investigations, the procedure followed at each plant was generally similar. Once plants in the same geographic region had agreed to participate, the project technical director visited each plant to review the plant layout; determine a proper location for installation of a composite sampler; initially educate plant personnel in their responsibilities to extract and store samples; advise the necessity for obtaining concurrent information on production and waste volume; observe waste treatment facilities, and agree upon a date to begin waste sampling.

On the agreed date, the field engineer arrived at the plant. He carried with him all the equipment necessary for the sampling program. Equipment used throughout the study is listed below:

- Three N-Con "Surveyor" samplers, each with intake and exhaust hoses, 0.64 cm opening intake basket screen, 9.5 liter sample collection container, and a 30 m. extension cord.
- One Brailsford "EV-1" sampler with accessories.
- One Brailsford "DU-2" sampler with accessories.
- Six Coleman insulated coolers - made of heavy plastic with locking lid.
- 120 0.95 liter plastic sample bottles with twist-on lids.
- 180 1.9 liter sample bottles with twist-on lids.
- 300 printed information tags with wire for fastening to sample bottles.
- One portable Beckman automatic pH meter.
- Two thermometers for water temperature measurements.
- 70 heavy cardboard boxes with styrofoam lining for sample shipping.
- 91 kg. of dry ice purchased from ice houses or donated by food plants for sample preservation during shipping.

At each plant, the field engineer installed the automatic sampling unit at a site pre-selected by the project director and plant staff. The sampling sites were located to obtain representative samples of screened raw waste prior to pretreatment units. Areas of turbulence were chosen to insure mixing and suspension of solids. Once the engineer had installed the sampler, he instructed the plant personnel in proper sampler operation and sample handling. In most cases this involved merely turning the unit on and off at the beginning and end of shifts, filling a sample bottle from the large 9.5 liter sample collection container, after swirling the latter to achieve a homogeneous wastewater solution, and placing the sample in the Coleman cooler in the plant freezer. The engineer also advised plant managers as to what supplemental data would be needed on production tonnages and wastewater volumes and urged them to compile this information during the sampling period.

During the sampling period, the investigator returned to the plant every 3 or 4 days to insure proper operation and to pick up frozen samples. These samples were packed in dry ice in the styrofoam lined boxes and transported by the quickest means to the NCA Laboratory in Berkeley, California. Most of the samples were shipped air freight to San Francisco for pickup by the laboratory. Samples collected from plants in northern California were delivered by car to the laboratory the same day.

At the end of the sampling period, the engineer picked up the last of the frozen samples, shipped them to the lab, and acquired whatever volume and production data was available at that time.

Sampling frequency, type, and procedures were somewhat dependent upon circumstances found at each plant. Approximately ten "end of pipe" time interval composite samples for ten consecutive operating days were collected at each plant. These samples were generally 24 hour composites, but exceptions were made due to plant operation or collection time requirements. If distinct "processing" and "clean-up" shifts existed, samples of each shift were taken along with related wastewater volume data. At two of the plants (S and T), additional grab samples were taken of major waste streams (i.e., sauce room clean-up). Some food plants investigated had their own permanent automatic sampler. In these situations, the field engineer supplied the sample bottles, and storage cooler. Plant personnel took their routine composite samples and divided the sample for use by this study, and for their own analysis work.

ANALYSIS

When shipments of samples arrived at the NCA lab, they were kept frozen until lab analysis was to begin. Samples were analyzed for the following constituents using the standard procedures listed below:

Test	Procedure
. COD	Standard methods (13th edition)

Test	Procedure
. BOD	Standard methods: 5-day, 20°C, cylinder dilution procedure.
. SS	Standard methods using glass fiber filter paper.
. VSS	Standard methods.
. Total P	From Methods for Chemical Analysis of Waste and Water, EPA, 1971, 16020 -- 07/71.
. TKN	Standard methods.
. Grease and oil	From Methods for Chemical Analysis of Waste and Water, EPA, 1971, 16020 -- 07/71.

Two of the 26 plants studied (E, P) were not sampled, but provided comprehensive historical information on wastewater concentrations, volumes, and production weights. Productivity factors were calculated from this data just as it was for the other plants. Appendix B provides a detailed explanation of the methods of productivity factor calculation used for each of the 26 plants.

The field work was accomplished successfully, considering the number and distribution of the plants involved, but not without problems. The most difficult task was the scheduling of sampling periods at a group of plants in the same geographical area while all those plants were in representative production. The project team had optimistically anticipated being able to sample five plants in an area (200 mile radius) concurrently and then moving on to the next area. Practically this proved impossible to coordinate, and generally only two or three plants were being sampled concurrently. This caused an overrun of project schedule and substantially more travel expense than anticipated.

Another problem encountered was the inherent inability of the Brailsford samplers to take representative samples with respect to suspended solids. These units utilize a small suction pump which slowly draws a small volume of sample up a .64 cm. intake tube into the container. It seems probable that the suspended solids content of the sample is lower than actual because solids tend to settle by gravity down the intake tube during the off periods in the pumping cycle. The Brailsford samplers should be used only on wastewaters with low solids concentrations, which is usually not the case at food plants. No problems were experienced with the N-Con sampler. This unit provides representative samples because it uses a more powerful pump to draw large sample volumes through the 1.3 cm. intake hose and pump impeller before diverting a small part of the flow into the sample container.

Another hindrance to efficient data analysis was the long delay in getting production and/or wastewater volume data from some of the plants. Proper authorization must often come from company headquarters and once sampling has ended, it is often difficult to obtain the information needed through follow-up phone calls and letters. These delays can be minimized by early explanation to plant personnel as to what data is needed, and by constant reminders when the field engineer makes his stops to pick up samples.

APPROACH TO CATEGORIZATION

Categorization of the specialty foods industry is made complex by the great number of plants and wide diversity of products. In addition, many plants make several products and it is virtually impossible to relate wastewater characteristics back to a certain product because a variety of products are processed simultaneously, and the mix is often continually changing. Another hindrance to categorization is the fact that although two plants may produce virtually the same final products, one may employ more intensive raw material processing than the other, and thus their wastewater properties could vary significantly. Moisture content of products can vary between product styles, affecting productivity factors based on final product weight.

Other factors which may have a significant effect upon wastewater generation from a particular plant include, plant size, number of shifts, percentage of production capacity in use, cost of water supply and wastewater disposal, degree to which ingredients have been pre-processed elsewhere,managements desire to reduce waste generation, and economic ability of the plant to modernize equipment.

Each of the factors described above may have an important effect upon waste generation from a particular plant. This study obtained data from an average of less than three plants per category. Considering the many uncontrollable variables involved and the limited number of plants investigated, the category selections and wastewater characteristics presented in this report should be considered as preliminary.

In order to obtain the most equitable categorization, within the bounds of the scope of work, we have based our decisions for plant groupings on three basic factors:

- Primarily: Type of product.
- Secondarily: a) Type and degree of raw material processing, b) wastewater productivity factors (kg pollutant/kkg product).

The advantages of this approach to industrial categorization are as follows:

- Simplicity and ease of initial categorization - rough grouping by "type of final product" is a comparatively simple task and provides a point of departure for more detailed analysis. After "product" grouping, processing differences or wastewater characteristics can be reviewed to further substantiate categorial selections or to reclassify the plants that appear misplaced.
- Provides easy comparison to other plants - grouping by product allows members of the specialty food industry to compare their overall plant wastewater characteristics to similar plants preparing the same products.
- Good probability of similarity in other parameters - plants initially grouped by product type frequently show good correlation in overall wastewater properties (concentrations, volume per unit product, etc.) if similar raw ingredient processing operations are performed.

Final category selections are described in the following section.

SECTION V

CATEGORIZATION AND WASTEWATER CHARACTERISTICS

As previously described in Section IV, field investigations of liquid waste characteristics were performed at 24 specialty food plants, and historical data acquired at an additional two plants. Individual case studies of these plants are found in Appendix A and provide details of wastewater volumes, pollutant concentrations, products, and ingredients. Simplified process flow diagrams, when obtained, accompany the case studies. The plants are designated by letter (A, B, etc.) and located only by very broad geographical area (West, Mid-West, East). This was done to protect the confidentiality of the information provided.

In this chapter, wastewater characteristics are detailed and discussed specifically for each category. Comparisons are drawn where significant and discussions of individual plants provide explanation of typical results.

In full recognition of the difficulties involved in categorizing a complex industry of over 2,000 plants, the following ten categories were established for the purpose of this investigation.

- Category 1 - Prepared Dinners
- Category 2 - Frozen Bakery Products
- Category 3 - Dressings, Sauces and Spreads
- Category 4 - Meat Specialties
- Category 5 - Canned Soups and Baby Foods
- Category 6 - Tomato-Cheese-Starch Combinations
- Category 7 - Sauced Vegetables
- Category 8 - Sweet Syrups, Jams and Jellies

- Category 9 - Chinese and Mexican Foods
- Category 10 - Breaded Frozen Products

PREPARED DINNERS (Category 1)

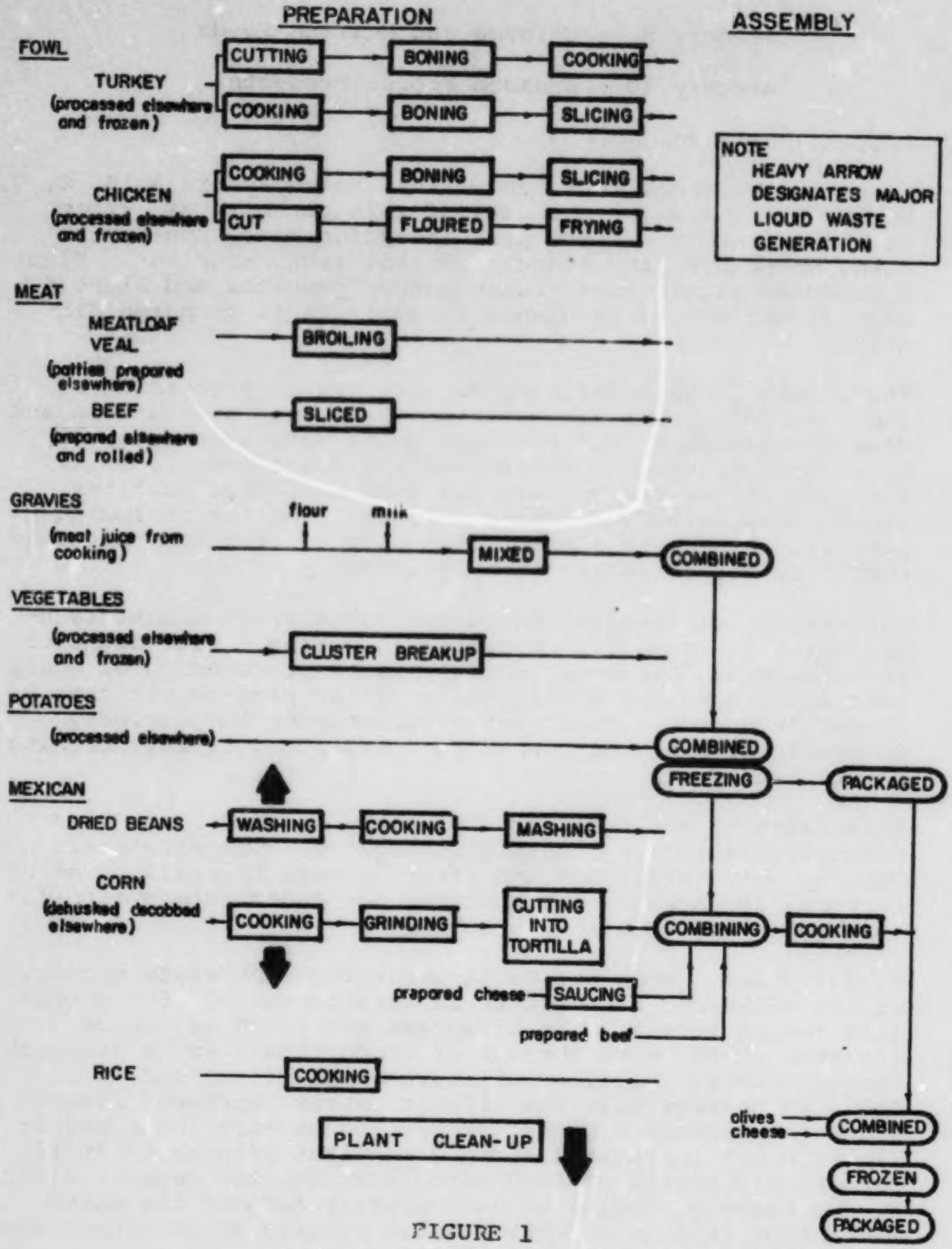
Plant letter codes included in this category are A, B, C, D, E, and F. The major products of this category are frozen prepared dinners and pot pies including meat, poultry or fish, vegetable, and starch (potato, rice, noodles). Plant A produces significant frozen bakery products and Plant E significant vegetable dishes in addition to prepared dinners.

The plants in this category do very little processing of raw materials. The meat portions have been slaughtered and dressed elsewhere, and the vegetables have also generally been pre-processed elsewhere and shipped frozen in bulk. The ingredients are usually cut into meal size portions, cooked, assembled and frozen. Figure 1 on the following page illustrates in a simplified flow diagram the "assembly plant" nature of plants in this category.

The primary wastewater generating activity is plant clean-up, which is generally concentrated during a late night or early morning "clean-up" shift. However, cleaning of equipment is carried out continuously as the product mix changes or spills occur. Other wastewater sources may include, vegetable rinsing and blanching operations, frying, cooking, and cooling water.

This category was the most thoroughly covered of the ten categories with six plants investigated. The plants are usually very large, and are often located in small towns or in rural areas where their wastes may constitute a significant potential treatment problem.

Tables 2 and 3 show the waste generation and waste strength of the effluents from plants in this category. BOD generation ranges from 9 to 34 kilograms per 1,000 kilograms (kg/kkg) or 18 to 68 lbs/ton of production. Waste strength varies from 600 to 4,000 milligrams per liter (mg/l) of BOD. We believe that the highest levels represent plants which (1) produce a higher proportion of rich foods and/or (2) have not instituted a rigid in-plant program to avoid excessive disposal of food materials into the sewer. Plant E, for example, claims to have greatly reduced its waste generation through a comprehensive program of personnel education and in-plant modifications.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FRYING
NOTE
HEAVY ARROW DESIGNATES MAJOR LIQUID WASTE GENERATION
MEAT
MEATLOAF
VEAL
(patties prepared elsewhere)
BROILING
BEEF
(prepared elsewhere and rolled)
SLICED
GRAVIES
(meat juice from cooking)
flour
milk
MIXED
COMBINED
VEGETABLES
(processed elsewhere and frozen)
CLUSTER BREAKUP
POTATOES
(processed elsewhere)
COMBINED
FREEZING
PACKAGED
MEXICAN
DRIED BEANS
WASHING
COOKING
MASHING
CORN
(dehusked decobbed elsewhere)
COOKING
GRINDING
CUTTING INTO TORTILLA
COMBINING
COOKING
prepared cheese
SAUCING
prepared beef
RICE
COOKING
PLANT CLEAN-UP
olives
cheese
COMBINED
FROZEN
PACKAGED

FIGURE 1

PREPARED DINNER PLANT
SIMPLIFIED PROCESS FLOW DIAGRAM

Table 2. CATEGORY 1, AVERAGE POLLUTANTS CONTAINED IN WASTEWATER PER UNIT PRODUCTION

Plant code	Constituent (kg/kkg finished product)							
	COD	BOD	SS	VSS	Total P	TKN	Grease and oil	Volume (l/kkg)
A	69	35	34	33	0.25	0.44	44	8,700
B	42	18	11	11	0.18	0.25	21	6,200
C	28	13	11	11	0.24	0.61	-	22,000
D	27	15	14	14	0.16	0.55	2.9	21,000
E	20	11	6.6	6.0	-	-	3.8	9,400
F	17	8.8	6.2	6.2	0.12	0.37	4.8	4,400
Average	34	17	14	14	0.19	0.44	15	12,000
Range	17- 69	9- 34	6- 34	6- 33	.12- .25	.25- .61	2.9- 44	4,400- 22,000

Table 3. CATEGORY 1, AVERAGE WASTEWATER CHARACTERISTICS

Plant code	Concentration (mg/l)						
	COD	BOD	SS	VSS	Total P	TKN	Grease and oil
A	7,900	4,000	3,900	3,800	29	51	5,100
B	6,800	2,900	1,800	1,700	30	34	3,400
C	1,300	620	530	510	11	28	-
D	1,300	720	680	650	7.6	26	140
E	2,100	1,240	700	640	-	-	400
F	3,800	2,000	1,400	1,400	28	85	1,100
Average	3,900	1,900	1,500	1,500	21	45	2,000
Range	1,300- 7,900	620- 4,000	530- 3,900	510- 3,800	7.6- 30	26- 85	140- 5,100

FROZEN BAKERY PRODUCTS (Category 2)

Plant letter codes included in this category are G and H. The major products of this category are frozen bakery dessert products such as cakes, pies, brownies, cookies, rolls, and other desserts.

The plants are very large scale kitchens which purchase the ingredients such as butter, flour, shortening, eggs, sugar, flavoring, fruit filling, etc., in much the same way as the housewife would were she making the baked goods from scratch. Plants G and H are both major producers of these products with national distribution.

Tables 4 and 5 summarize the waste generation and waste strength of the effluents from the two bakery products plants. Waste strength is very high with BOD in the range of 2,100 to 4,300 mg/l. Unfortunately, Plant H would not provide production information, making it impossible to determine the average pollutants per unit of production for this plant.

Table 4. CATEGORY 2, AVERAGE POLLUTANTS CONTAINED IN WASTEWATER PER UNIT PRODUCTION

Plant code	Constituent (kg/kkg finished product)							
	COD	BOD	SS	VSS	Total P	TKN	Grease and oil	Volume (l/kkg)
G	52	23	14	14	0.082	0.30	11	11,000
H	No Production Information Provided							

Waste is generated from clean-up of spills and equipment and from the disposal of substandard ingredients and products. The major ingredients are very rich and high in BOD, suspended solids, and grease. Variations in frequency of product mix changes and house cleaning practices help to account for differences in effluent concentrations.

Table 5. CATEGORY 2, AVERAGE WASTEWATER CHARACTERISTICS

Plant code	Concentration (mg/l)						
	COD	BOD	SS	VSS	Total P	TKN	Grease and oil
G	4,600	2,100	1,300	1,200	7.8	27	940
H	9,300	4,300	3,100	3,000	5.7	45	690
Average	7,000	3,200	2,200	2,100	6.8	36	820

DRESSING, SAUCES AND SPREADS (Category 3)

Plant codes I and J are included in this category. Major products are salad dressings, mayonnaise, mustard and barbecue sauces. Typical ingredients include tomato paste, vegetable oil, spices, eggs, vinegar, mustard, and small quantities of dairy products. Generally, the ingredients are blended, bottled, cooked, and cooled. Clean-up of the blending and cooking vats contributes most of the waste load.

The two plants sampled were a very small batch type plant (J) and one of the nation's largest plants (I). As seen from Tables 6 and 7 correlation was surprisingly good between the plants. Both exhibited very strong wastes with average BOD of 2,600 mg/l, however, waste generation in terms of production averaged a low 7.5 kg/kkg (15 lb/ton) of product. Wastewater volume averaged only 2,800 l/kkg (670 gal/ton) of product.

Table 6. CATEGORY 3, AVERAGE POLLUTANTS CONTAINED IN WASTEWATER PER UNIT PRODUCTION

Plant code	Constituent (kg/kkg finished product)							
	COD	BOD	SS	VSS	Total P	TKN	Grease and oil	Volume (l/kkg)
I	12	5.6	2.6	2.4	0.039	0.036	3.1	2,600
J	14	9.4	4.4	4.4	0.018	0.038	8.3	3,100
Average	13	7.5	3.5	3.4	0.028	0.037	5.7	2,800

Table 7. CATEGORY 3, AVERAGE WASTEWATER CHARACTERISTICS

Plant code	Concentration (mg/l)						
	COD	BOD	SS	VSS	Total P	TKN	Grease and oil
I	4,900	2,300	1,000	960	16	15	1,300
J	4,500	3,000	1,400	1,400	5.8	12	2,700
Average	4,700	2,600	1,200	1,200	11	14	2,000

The overall low productivity factors for this category are due to the fact that equipment clean-up is the primary wastewater producing activity, and relatively small volumes of water are used. One misleading factor in the low productivity and wastewater generation factors is that water is a major weight component in the final product and most of the initial ingredients. This tends to make the production tonnages artificially high compared to other categories preparing low water content products. Final productivity factors would be substantially higher for this category if only product dry weight was considered.

Plant I has installed an automatic flow-proportional composite sampler with refrigerated storage. Samples are taken daily and analyzed for BOD and SS in the plant quality control laboratory. Plant management uses raw waste strength as a gauge of their in-plant efficiency in minimizing waste of valuable ingredients into the sewer. They informed our investigator that if the weight of BOD in the raw waste exceeds one percent of the production weight they investigate to determine the reason. As shown in Table 6, the BOD during our sampling period averaged only 0.56 percent of the production weight. Incidentally, the BOD and SS results of the plant laboratory analyses for the sampling days corrolated very closely with the BOD and SS results of the NCA Laboratory analyses run on the frozen samples.

MEAT SPECIALTIES (Category 4)

Plant codes K and L are included in this category. Major products are ham, sausages, stews, pickled meats, hash, and chile, plus frozen items such as pre-fried meat patties.

The meats have been slaughtered, dressed and packed elsewhere. Added ingredients are largely spices and preservatives. Substantial quantities of grease and oil are present in the waste flow from the cleaning of cooking vats, frying ovens, and other equipment which comes in contact with the meat.

The two plants sampled represented opposite ends of the meat specialties category in terms of amount of processing performed. Plant K is a very small operation preparing a limited number of products. Processes include grinding, mixing with additives, then canning and cooking or patty forming and freezing. Minimal amounts of water are used for clean-up activities. Plant L on the other hand is a large meat canning operation preparing a wide assortment of meat specialties. Processing is more extensive, product changes more frequent, and waste generation significantly higher than Plant K.

Tables 8 and 9 show the waste generation and strengths recorded for the two plants. We believe that Plant L is more typical of plants producing meat specialties, with BOD values of 16 kg/kkg (32 lbs/ton) of production and 1,100 mg/l concentration. Also, we believe the sampler used at Plant K may not have taken representative samples due to low flow volume in the sampler suction tube.

Table 8. CATEGORY 4, AVERAGE POLLUTANTS CONTAINED IN WASTEWATER PER UNIT PRODUCTION

Plant code	Constituent (kg/kkg finished product)							
	COD	BOD	SS	VSS	Total P	TKN	Grease and oil	Volume (l/kkg)
K	5.1	3.0	1.2	0.97	0.086	0.16	0.68	5,700
L	33	16	11	10	0.11	0.98	7.3	15,000
Average	19	9.5	6.1	5.5	0.098	0.57	4.0	10,000

Table 9. CATEGORY 4, AVERAGE WASTEWATER CHARACTERISTICS

Plant code	Concentration (mg/l)						
	COD	BOD	SS	VSS	Total P	TKN	Grease and oil
K	900	530	210	170	15	28	120
L	2,300	1,100	720	670	6.7	67	490
Average	1,600	820	460	420	11	48	300

CANNED SOUPS AND BABY FOODS (Category 5)

Plant codes M and N are included in this category. Canned soups and baby foods, are put in one category because the plants typically are large, and produce many product varieties which contain different vegetable, meat, starch, and fruit ingredients. Both plants perform significant raw product processing of vegetables, as reflected by the relatively high wastewater generation figures shown in Tables 10 and 11. In this respect they are more closely allied with straight commodity processors than with many other categories of the specialty foods industry. Major wastewater sources are plant clean-up; washing, trimming, blanching of raw vegetables; washing, peeling and coring of raw fruit; and cooking of meat. Generally, waste discharges will vary greatly in volume and strength, depending upon which varieties are being manufactured, and the relative quantities of raw commodities and pre-processed ingredients.

Table 10. CATEGORY 5, AVERAGE POLLUTANTS CONTAINED IN WASTEWATER PER UNIT PRODUCTION

Plant code	Constituent (kg/kkg raw product)							
	COD	BOD	SS	VSS	Total P	TKN	Grease and oil	Volume (l/kkg)
M	14	8.5	4.3	3.1	0.068	0.19	-	15,000
N	27	15	10	8.4	0.29	0.75	2.4	29,000
Average	20	12	7.2	5.8	0.18	0.47	-	22,000

Table 11. CATEGORY 5, AVERAGE WASTEWATER CHARACTERISTICS

Plant code	Concentration (mg/l)						
	COD	BOD	SS	VSS	Total P	TKN	Grease and oil
M	1,000	590	280	210	4.1	12	—
N	940	520	360	290	10	26	82
Average	970	560	320	250	7.0	19	—

TOMATO-CHEESE-STARCH COMBINATIONS (ITALIAN SPECIALTIES) - Category 6

Plant codes O, P, Q and R are included in this category. Major products are canned and frozen spaghetti, lasagne, ravioli, frozen pizza, and other Italian specialties made with tomato, starch, and cheese base. These plants were placed in one category because they typically have the three principal ingredients listed, all of which are pre-processed elsewhere. The wastes are generated primarily from spills and clean-up of blending vats and cooking kettles.

As seen from Tables 12 and 13 this category showed poor correlation in waste generation. We believe this wide diversity is due to selection of three plants which are vastly different in their operations due to size, product style, and percent of total plant capacity being used at the time of sampling.

Plant R is the smallest operation covered in this study. Processing is done largely by hand. Virtually no water is used except for end of the day clean-up of equipment. As shown in the tables, wastewater generation was extremely low (1,800 l/kkg or 430 gal/ton product). This minimal clean-up flow provided little dilution, thus the high concentrations. However, the wastewater volume was so low that even the higher strength of the waste could not significantly effect the productivity factor. The 2.6 kg COD/kkg product factor was the lowest of all 26 plants investigated.

Plant O is a new plant operating at only a fraction of its design capacity. With increased production to optimum levels, the use of water for clean-up purposes is expected to become more efficient in terms of volume per unit production and cause the present high productivity factors and

Table 12. CATEGORY 6, AVERAGE POLLUTANTS CONTAINED IN WASTEWATER PER UNIT PRODUCTION

Plant code	Constituent (kg/kkg product)							
	COD	BOD	SS	VSS	Total P	TKN	Grease and oil	Volume (l/kkg)
O	39	19	14	13	0.79	0.59		80,000
P	-	3.3	-	-	-	0.12		9,800
Q	8.8	5.2	3.4	3.1	0.052	0.15	4.7	26,000
R	2.6	1.1	0.65	0.59	0.011	0.061		1,800
Average	17	7.2	6.0	5.6	0.28	0.23		29,000

Table 13. CATEGORY 6, AVERAGE WASTEWATER CHARACTERISTICS

Plant code	Concentration (mg/l)						
	COD	BOD	SS	VSS	Total P	TKN	Grease and oil
O	500	240	180	150	10	7.6	
P	-	340	-	-	-	11.8	
Q	340	200	130	120	2.0	5.6	180
R	1,500	690	360	330	6.0	34	
Average	780	370	220	200	6.0	15	

wastewater generation to drop significantly. This plant also prepares institutional salads. Significant amounts of wastewater are generated by the washing of lettuce and blanching of other salad ingredients.

Plant P is a very large plant which produces canned tomato-cheese-starch products. These canned products contain larger volumes of water than do similar frozen items. High product water content generates artificially high production weights and thus lowers substantially the effluent productivity factors.

To summarize Category 6 we believe that none of the plants sampled could be called a "typical" situation. It is entirely possible, however, that the pollutant generation levels shown in Table 12 result in reasonable average values for this category in spite of the wide ranges.

SAUCED VEGETABLES (Category 7)

Only Plant S whose major product is frozen vegetables with and without cheese or butter sauce was sampled in Category 7. This category represents plants whose wastes are largely generated by the washing, peeling, cutting, blanching, and cooking or freezing of raw vegetables. The addition of butter sauce, tomato sauce, spices, etc. may technically place this plant under the specialty food category, however, we believe the waste load is similar to that of a straight vegetable processor, with added waste load from spillage and clean-up of sauce equipment.

Plant S generates exceptionally high wastewater volume due to inefficient water use in the washing, cutting, cooling and transporting of the produce. The plant is about twenty-five years old and was designed at the time that water conservation and wastewater volume reduction were not considered important. Little modernization of equipment has been implemented, and the plant owners will soon be faced with the choice of large expenditures to reduce volumes discharged to the city sewer, or shut-down. The large volume provides dilution of pollutant concentrations and the plant effluent has a low BOD concentration of 310 mg/l.

As can be seen from Tables 14 and 15. the sauce room clean-up wastewater is high in strength, being comprised of cheese, margarine and shortening; but it is insignificant in volume (less than 1 percent of the total wastewater flow). The sauce room waste accounts for about 15 percent of the total plant COD and BOD loads, 7 percent of the SS load, 27 percent of the total phosphorus load (phosphorus containing detergents used for sauce room clean-up), and 4 percent of TKN.

Table 14. CATEGORY 7, AVERAGE POLLUTANTS CONTAINED IN WASTEWATER PER UNIT PRODUCTION

Plant code S	Constituent (kg/kkg finished product)						
	COD	BOD	SS	VSS	Total P	TKN	Volume (l/kkg)
24-hour plant raw wastewater	45	25	21	16	0.33	1.1	85,000
Sauce room clean-up wastewater	6.4	3.5	1.4	1.3	0.090	0.047	490

On the basis of this one plant, it appears that the rapid growth in the sale of sauced vegetables will increase the pollution load generated by the vegetable processing industry.

Table 15. CATEGORY 7, AVERAGE WASTEWATER CHARACTERISTICS

Plant code S	Concentration (mg/l)					
	COD	BOD	SS	VSS	Total P	TKN
24-hour raw wastewater	560	310	250	200	4.4	13
Sauce room clean-up wastewater	14,000	8,000	3,300	3,100	230	100

SWEET SYRUPS, JAMS AND JELLIES (Category 8)

Plant codes T and U fall into this category. Major products are syrups, fruit toppings, jams, jellies, and preserves. Typically, the ingredients include fruit, sugar, chocolate, nuts, cocoanut, and flavorings. Most ingredients are preprocessed elsewhere. The plants blend various proportions of ingredients, cook and package the products.

Plant U processed only jams, jellies, and spreads. Plant T processed a variety of sweetened products plus jello, chocolate, cocoanut and instant rice. In spite of its variety of products, Plant T was placed in this category because the instant rice processing water is separately disposed and not included in Tables 16 and 17, and the chocolate, cocoanut and jello are very dry processes which contribute less wastewater than does the syrup operation.

As seen from the tables the wastes are strong in dissolved organic strength, but relatively low in pollutant load per unit weight of production. Major wastewater generation is from clean-up of mixing vats and cookers during changes in product runs and at the end of each day. Apparently, clean-up operations were efficient as indicated by low wastewater volumes for both plants.

Table 16. CATEGORY 8, AVERAGE POLLUTANTS CONTAINED IN WASTEWATER PER UNIT PRODUCTION

Plant code	Constituent (kg/kkg finished product)							
	COD	BOD	SS	VSS	Total P	TKN	Grease and Oil	Volume (l/kkg)
T	5.4	3.0	1.3	1.1	0.076	0.057	0.62	2,700
U	12	7.2	0.68	0.60	0.019	0.030	-	2,000
Average	8.7	5.1	1.0	0.85	0.048	0.044	-	2,400

Table 17. CATEGORY 8, AVERAGE WASTEWATER CHARACTERISTICS

Plant code	Concentration (mg/l)						
	COD	BOD	SS	VSS	Total P	TKN	Grease and Oil
T	2,000	1,100	470	410	28	21	230
U	6,100	3,600	340	300	9.6	15	-
Average	4,000	2,400	400	360	19	18	-

CHINESE AND MEXICAN FOODS (Category 9)

Included in this category are plant codes V, W and X. Major products are chinese specialties such as chop suey, chow mein, and fried rice; and Mexican specialties such as thick vegetable sauces, hot peppers and dip mix.

These plants correlated well because the product of all three plants is canned and high in vegetable content.

A substantial portion of the raw vegetables are processed at the plants while all other ingredients are pre-prepared elsewhere. Major waste flows originate from washing and blanching of vegetables, and from clean-up of mixing and cooking vats. Tables 18 and 19 show waste generation and strength. BOD generation averages 6.9kg/kkg 13.8 lbs/ton) of production and 570 mg/l.

Table 18. CATEGORY 9, AVERAGE POLLUTANTS CONTAINED IN WASTEWATER PER UNIT PRODUCTION

Plant code	Constituent (kg/kkg finished product)							
	COD	BOD	SS	VSS	Total P	TKN	Grease and Oil	Volume (l/kkg)
V	12	6.3	2.4	2.2	0.084	0.36	1.2	14,000
W	12	6.7	4.0	3.8	0.041	0.27	4.7	18,000
X	12	7.8	1.9	1.2	0.29	0.21	-	8,900
Average	12	6.9	2.8	2.4	0.14	0.28	3.0	14,000

Table 19. CATEGORY 9, AVERAGE WASTEWATER CHARACTERISTICS

Plant code	Concentration (mg/l)						
	COD	BOD	SS	VSS	Total P	TKN	Grease and Oil
V	830	450	170	160	6.0	26	85
W	670	370	220	210	2.3	15	260
X	1,300	900	210	140	34	22	-
Average	930	570	200	170	14	21	170

BREADED FROZEN PRODUCTS (Category 10)

Included in this category are plant codes Y and Z. Plant Y breads mushrooms, onions, and pre-processed perch after minimal washing. Plant Z prepares fish and shellfish that have been cleaned and dressed at a seafood processing plant. Generally, the seafood is thawed, washed, dried, dipped in batter, breaded and frozen. The breaded seafood is not fried. The major wastewater sources are plant clean-up, washing and rinsing of raw product, and thawing of frozen raw seafood in the case of Plant Z.

Tables 20 and 21 show the wastewater generation and strengths of the effluent from the two plants. Plant Z utilizes huge volumes of water to thaw and frequently wash the product. As a result, waste strength is a relatively low 400 mg/l BOD. Plant Y is primarily a producer of breaded onion rings. The batter is very rich and clean-up of equipment and spills results in a wastewater with an average BOD of 4,500 mg/l. In direct contrast to Plant Z, Plant Y operation generates very little wastewater but produces the strongest waste of all plants investigated.

Table 20. CATEGORY 10, AVERAGE POLLUTANTS CONTAINED IN WASTEWATER PER UNIT PRODUCTION

Plant code	Constituent (kg/kkg raw product)							
	COD	BOD	SS	VSS	Total P	TKN	Grease and Oil	Volume (l/kkg)
Y	40	15	23	23	0.12	0.33	1.2	3,300
Z	66	37	30	29	0.58	4.8	-	92,000
Average	53	26	26	26	0.35	2.6	-	48,000

Table 21. CATEGORY 10, AVERAGE WASTEWATER CHARACTERISTICS

Plant code	Concentration (mg/l)						
	COD	BOD	SS	VSS	Total P	TKN	Grease and Oil
Y	12,000	4,500	7,100	7,100	37	100	360
Z	720	400	330	320	6.3	52	-
Average	6,400	2,400	3,700	3,700	22	76	-

These plants illustrate the differences between two plants with similar major process techniques (i.e., raw product cleaning, cutting, battering, breading, freezing) but with different water usage patterns; one being a very wet operation and the other very dry.

SECTION VI

RAW WASTE LOADS, CURRENT TREATMENT TECHNOLOGY, AND PLANT DISTRIBUTION

STANDARD RAW WASTE LOADS

Great product diversity in this industry is reflected by large differences in waste generation between the different categories identified in Section V. Table 22 on the following page summarizes average wastewater productivity factors for all categories in terms of kilograms of pollutant per thousand kilograms of finished product. Figures 2 and 3 provide a graphical representation of similar data. Using COD as a measure of organic strength, Table 22 shows that category 10 (breaded frozen products) produces approximately 50 kg of COD per 1,000 kg of production (100 lbs/ton). The lowest category in terms of COD production is number 8 (sweet syrups, jams and jellies) in which the two plants sampled produced an average of only 9 kg of COD per 1,000 kg of production (18 lbs/ton). Values of BOD's generally ran about 50 percent of COD values in the samples analyzed.

Average values for other waste constituents shown in Table 22 generally indicate that the industry produces suspended solids (SS) which are highly organic (VSS), the wastes are often deficient in nutrients (Total P and N) which must be added for satisfactory biological treatment, that grease and oil are significant ingredients where substantial frying is done, and finally, that wastewater volumes vary greatly.

Table 23 summarizes average raw wastewater constituent concentrations for all categories. Figure 4 provides a graphical representation of similar data. With few exceptions the average results reflect typical food processing wastes which are very high in COD and BOD concentrations, and organic suspended solids. In general, the wastes are amenable to discharge into municipal systems for joint treatment. In certain instances, pre-treatment may be required for removal

TABLE 22. AVERAGE POLLUTANTS CONTAINED IN WASTEWATER PER UNIT OF PRODUCTION, BY CATEGORY

Category	Average productivity factors (kg/kkg product)							
	COD	BOD	SS	VSS	Total P	TKN	G&O	Volume (l/kkg)
1	34	17	14	14	0.19	0.44	15	12,000
2	52	23	14	14	0.082	0.30	11	11,000
3	13	7.5	3.5	3.4	0.028	0.037	5.7	2,800
4	19	9.9	6.1	5.5	0.098	0.57	4.0	10,000
5	20	12	7.6	5.8	0.18	0.47	2.4	22,000
6	17	7.2	6.0	5.6	0.28	0.23	4.7	29,000
7	45	25	21	16	0.33	1.1	-	85,000
8	8.7	5.1	1.0	0.85	0.048	0.044	0.62	2,400
9	12	6.9	2.8	2.4	0.14	0.28	3.0	14,000
10	53	26	26	26	0.35	2.6	-	48,000

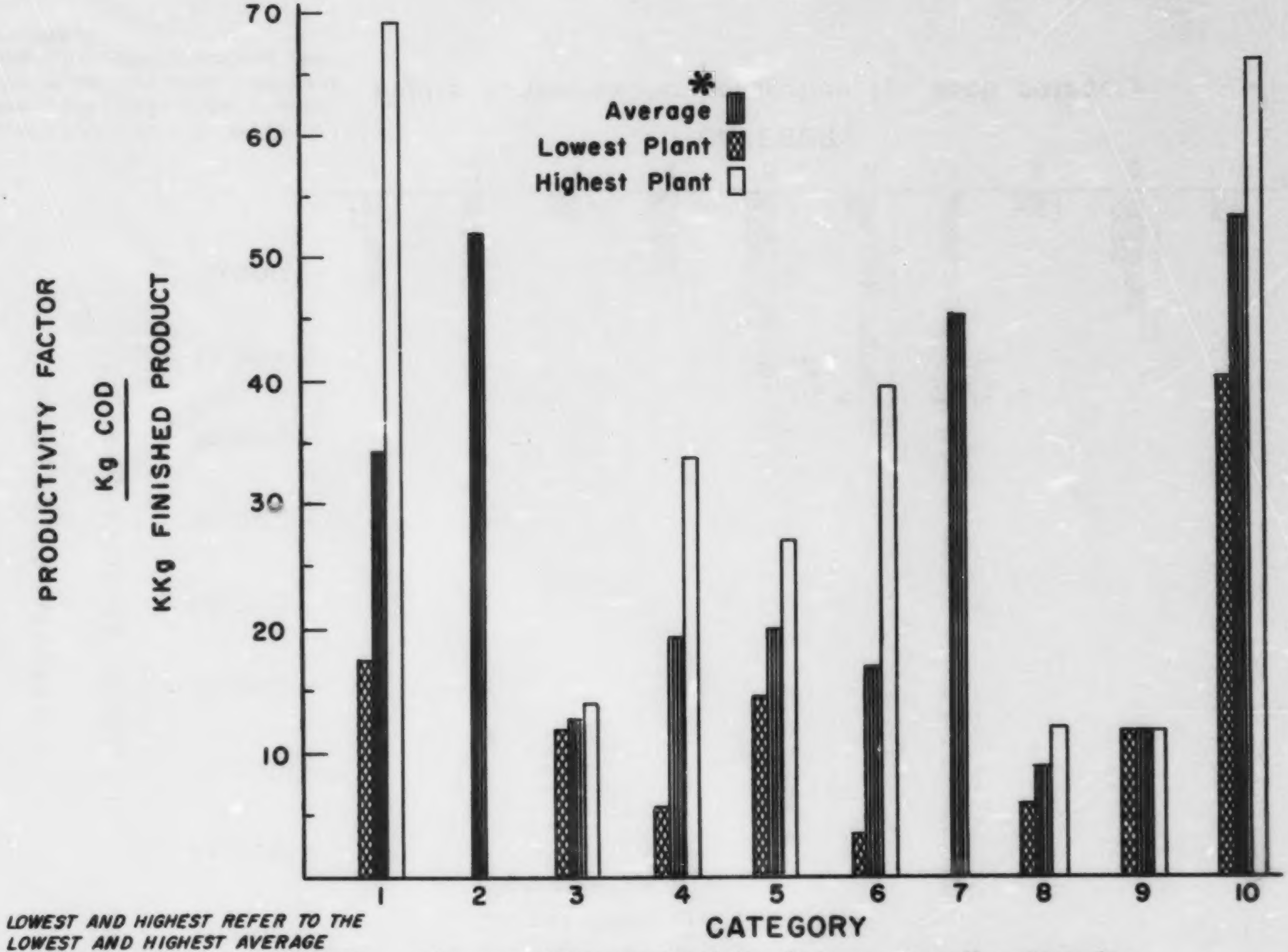
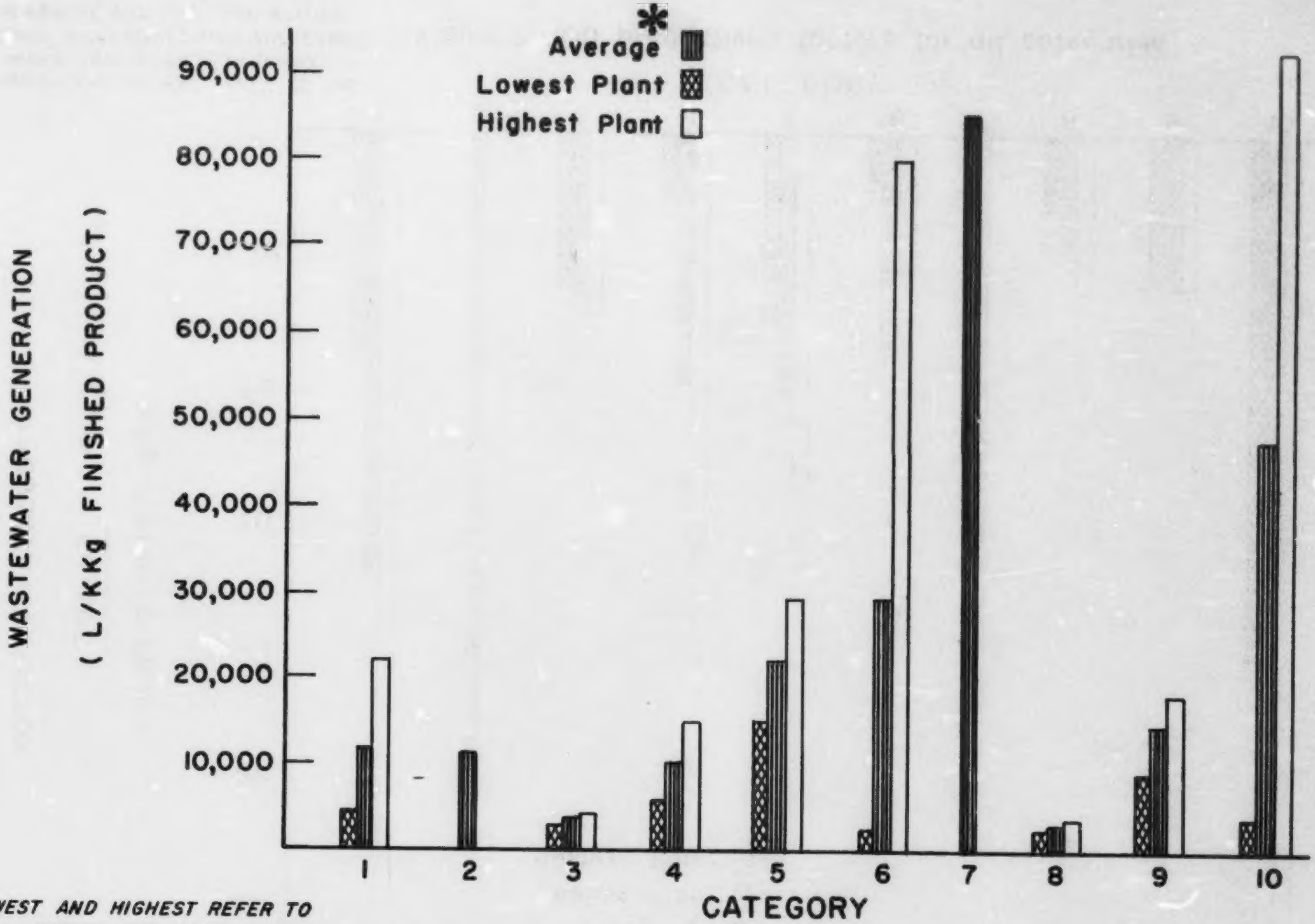


Figure 2. COD productivity factors for all categories

LOWEST AND HIGHEST REFER TO THE LOWEST AND HIGHEST AVERAGE PLANT EFFLUENTS OVER THE SAMPLING PERIOD, NOT ONE DAY VALUES



* *LOWEST AND HIGHEST REFER TO THE LOWEST AND HIGHEST AVERAGE PLANT EFFLUENTS OVER THE SAMPLING PERIOD, NOT ONE DAY VALUES.*

Figure 3. Wastewater generation for each category

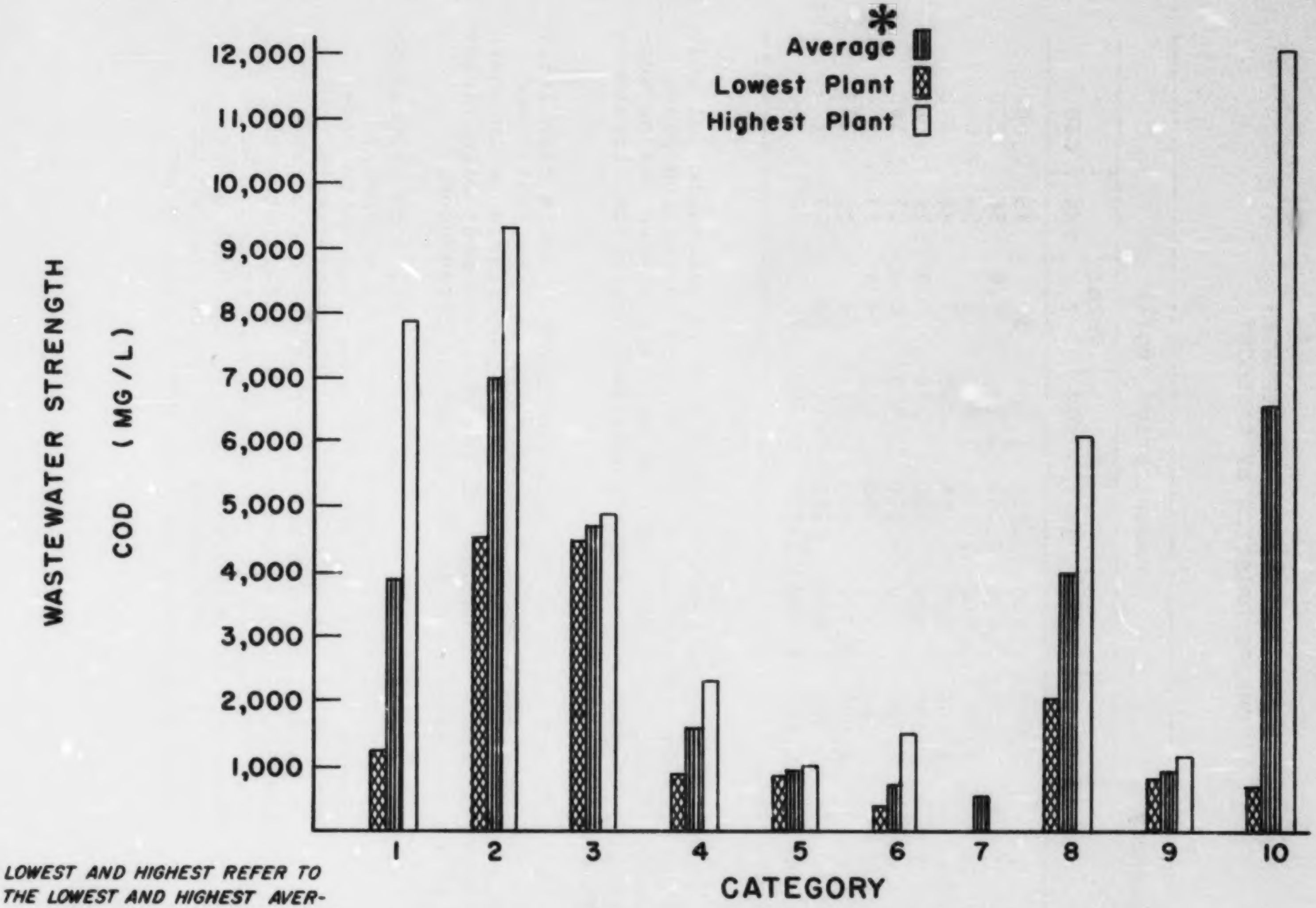


Figure 4. COD concentration for all categories

* *LOWEST AND HIGHEST REFER TO THE LOWEST AND HIGHEST AVERAGE PLANT EFFLUENTS OVER THE SAMPLING PERIOD, NOT ONE DAY VALUES.*

Table 23. AVERAGE WASTEWATER CHARACTERISTICS BY CATEGORY

Category	Concentration (mg/l)						
	COD	BOD	SS	VSS	Total P	TKN	G&O
1	3,900	1,900	1,500	1,500	21	45	2,000
2	7,000	3,200	2,200	2,100	6.8	36	820
3	4,700	2,600	1,200	1,200	11	14	2,000
4	1,600	820	460	420	11	48	300
5	970	560	320	250	7.0	19	82
6	780	370	220	200	6.0	15	180
7	560	310	250	200	4.4	13	-
8	4,000	2,400	400	360	19	18	230
9	900	570	200	170	14	21	170
10	6,400	2,400	3,700	3,700	22	76	360

of grease and oil to prevent deposition in the municipal collection system. Where the specialty food processing plant provides final treatment and disposal, the wastes can be successfully treated with properly designed biological treatment processes.

It is important to note the wide differences (more than 10:1) in waste strength between categories of the specialty food industry as shown in Table 23. This wide difference in waste strength is due to a variety of reasons, the most significant of which are summarized in the following paragraphs.

- Richness of product ingredients. All food processing plants undergo extensive clean-up of equipment, floors, spillages, etc. The principal waste components of the wash water are the ingredients used in product manufacture. Where these ingredients are high in fats, carbohydrates, sugar, etc. the resultant waste is correspondingly strong. As an example, the categories showing the high generation of organic wastes were frozen breaded products, which use a rich egg batter, and frozen bakery desserts which use large quantities of butter, eggs, and sugar.

- Number and type of processes performed. The plant process line may consist of many steps (cooking, blending, etc.) or very few. The individual process steps may contribute heavily to wastewater generation (blanching, washing, etc.) or very little. It was beyond the scope of this project to investigate wastes generated by individual process steps, however, even casual observation revealed the significance of this aspect.

- Number of different products and frequency of changes in product. As a rule when the type of product is changed all equipment in the process line is thoroughly cleaned. Therefore, plants which have relatively short runs of many different products generate more clean-up waste than do plants which run the same product for many days.

- Moisture content of ingredients and the final product. In this report pollution generation factors are calculated per unit weight of product. A major shortcoming of this approach is that the moisture of ingredients and products varies widely. For example, a canned spaghetti plant will produce less pollution per unit weight of production than a frozen pizza plant even though both are primarily a starch and tomato product. The canned spaghetti product has a much higher moisture content - therefore weighs more - and shows lower pollution productivity per unit weight of production.

- Management desire to reduce waste generation. Without question, a major factor in waste generation from any plant is the presence or absence of in-plant waste management programs designed to minimize waste disposal to the sewer.

- Other factors. A multitude of other factors may have a significant effect upon wastewater generation from a particular plant. These include, plant size, number of shifts, percentage of production capacity in use, cost of water supply and wastewater disposal, degree to which ingredients have been pretreated elsewhere, and economic ability of the plant to modernize equipment.

CURRENT TREATMENT TECHNOLOGY

The specialty food plants investigated exhibited a wide spectrum of wastewater treatment facilities from no treatment to extensive biological and physical-chemical systems. While evaluation of waste treatment systems was outside the scope of the project, a brief description of study team observations is provided.

Of the 26 plants investigated, 6 provided the equivalent of secondary treatment using biological systems in conjunction with other unit processes. The most extensive treatment facility observed is described in the case study for plant A (See appendix) and is reported to achieve in excess of 99 percent BOD reduction on raw waste with average BOD levels of 4,000 mg/l. The treatment facility has a design capacity of 350,000 gpd and is estimated by the owner to have a replacement value of approximately 3 million dollars. Other excellent secondary and tertiary treatment facilities were observed at Plants F, T and N. Plant D utilizes a land disposal system which has successfully operated for over 20 years.

Twenty-one of the 26 plants investigated discharged into municipal systems. Plants O and H provide activated sludge pre-treatment in order to reduce BOD levels 90 percent or more prior to discharge into the municipal sewer. Each is a large plant located in a small community. Plant V provides only screening on its' waste, but is reported to have a long term arrangement with the small community where it is located whereby the company pays approximately 85 percent of all capital and operating costs for municipal sewage treatment facilities.

Of the other 18 plants investigated, 4 provided no pretreatment, 2 provided grease traps only, and the remainder provided various degrees of screening, settling, or flotation prior to discharge to sewers. Several clarification operations utilized chemical treatment for pH adjustment and to promote coagulation.

Table 24 summarizes the treatment at each plant investigated. There is no corrolation between category and degree or type of treatment.

Table 24. SPECIALTY FOOD PLANT WASTEWATER TREATMENT OPERATIONS

Treatment	Plants utilizing
. None	J, R, U, Y
. Collection baskets in drains (only)	E
. Grease trap (only)	F, K
. Screening	A, C, M, N, P, Q, S, T, V, W, Z
. Settling	A, B, C, D, F, G, H, I, L, N, T, X
. Coagulation	B, N, W
. Trickling filtration	A, N
. Activated sludge	
. Conventional	A, H
. Extended aeration	O, T
. Lagooning	
. Anaerobic	A
. Aerobic	P
. Aerated	F, N, P
. Dissolved air flotation	A, B, F, N, W
. Chlorination	A, F, N, P
. Sand filtration	F
. Land disposal (partial or total)	D, N, P

PLANT DISTRIBUTION

Table 25 on the following pages lists the number of specialty food plants in each state by category. The table was compiled by the AFFI staff, using the best industry directory information available.(1,2,3) A total of 2,321 specialty food plants are shown, with the largest number in the states of California, New York, Illinois and Pennsylvania. Meat specialties and breaded frozen products have the largest number of individual plants among the categories.

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(1) American Frozen Food Institute Membership Directory - 1974 Edition.

(2) The Directory of the Canning, Freezing, Preserving Industries, 1970-1971, Published by Edward E. Judge & Sons.

(3) Quick Frozen Foods, 1972 Directory of Frozen Food Processors, Published by Conover-Mast Publications, Division of Cohners Publishing Co., Inc.

Table 25. DISTRIBUTION OF SPECIALTY FOOD PLANTS BY CATEGORY AND STATE

Categories	State									
	AL	AZ	AK	AR	CA	CO	CT	DE	FL	GA
1. Prepared dinners	1	1		3	25	2	4	1	4	2
2. Frozen bakery products			4	3	29	2	5	1	5	3
3. Dressings, sauces & spreads	1	2		2	21	2	1	1	4	1
4. Meat specialties	12	3		10	42	5	8	1	13	15
5. Soups and baby foods				1	15		2		6	1
6. Tomato-cheese-starch comb.		1		3	15	1	1	1	1	2
7. Sauced vegetables	1			2	43	2		3	5	2
8. Sweet syrups, jams & jellies					14					3
9. Chinese & Mexican foods		1		3	20	1	3	2	4	4
10. Breaded frozen products	7	1	18	4	48	1	2	4	40	6
TOTAL	22	9	22	31	272	16	26	14	82	39

Table 25 (continued). DISTRIBUTION OF SPECIALTY FOOD PLANTS BY CATEGORY AND STATE

Categories	State									
	MA	MI	MN	MS	MO	MT	NE	NV	NH	NJ
1. Prepared dinners	6	3	8		7		4	1		14
2. Frozen bakery products	5	14	6	1	10		5			13
3. Dressings, sauces & spreads	4	4	4	1	5		3		1	10
4. Meat specialties	9	14	12	7	5	1	10	1	1	19
5. Soups and baby foods	1	2	3	1			4		1	8
6. Tomato-cheese-starch comb.	1	1	4	1			3			6
7. Sauced vegetables	3	11	1		1		2			4
8. Sweet syrups, jams & jellies	6				1				1	2
9. Chinese & Mexican foods	11	5	6		2		4			18
10. Breaded frozen products	38	8	7	6	5		7			13
TOTAL	84	62	51	17	36	1	42	2	4	107

Table 25 (continued). DISTRIBUTION OF SPECIALTY FOOD PLANTS BY CATEGORY AND STATE

Categories	State									
	NM	NY	NC	ND	OH	OK	OR	PA	RI	SC
1. Prepared dinners		26	2		8		3	8	1	1
2. Frozen bakery products		25	4	1	13	4	8	12		1
3. Dressings, sauces & spreads		19	1		9	5	1	13	2	1
4. Meat specialties		40	4	2	27	9	4	33	3	2
5. Soups and baby foods		14	1		10			11	1	2
6. Tomato - cheese-starch comb.		11	1		1		2	2		1
7. Sauced vegetables		12	1		5	1	30	14	1	
8. Sweet syrups, jams & jellies		7	1		2	4	2	9		
9. Chinese & Mexican foods	1	22	2		9	4	4	11	1	1
10. Breaded frozen products		43	7	1	1		11	20	6	2
TOTAL	1	219	24	4	85	27	65	133	15	11

Table 25 (continued). DISTRIBUTION OF SPECIALTY FOOD PLANTS BY CATEGORY AND STATE

Categories	State									
	HI	ID	IL	IN	IA	KS	KY	LA	ME	MD
1. Prepared dinners	1	1	28	4	4	2	1	2	2	6
2. Frozen bakery products	1	3	25	5	3			2	3	7
3. Dressings, sauces & spreads			13	5	2	1	2	6		10
4. Meat specialties		3	33	10	11	2	2	4	3	9
5. Soups and baby foods	1		9	3			3	3	2	8
6. Tomato - cheese-starch comb.		1	5	2				1		5
7. Sauced vegetables	1	9	7	4			1	2	1	5
8. Sweet syrups, jams & jellies	2	1	4	1		1	2	3		4
9. Chinese & Mexican foods	1	1	29	4				3		6
10. Breaded frozen products		11	24	3	1		2	26	6	28
TOTAL	7	30	177	41	21	6	13	52	17	88

Table 25 (continued). DISTRIBUTION OF SPECIALTY FOOD PLANTS BY CATEGORY AND STATE

Categories	State										
	SD	TN	TX	UT	VT	VA	WA	WV	WI	WY	Total
1. Prepared dinners		5	6		1	4	5		4		211
2. Frozen bakery products		6	7	2	1	4	6		4		253
3. Dressings, sauces & spreads		2	12	2		1	4		6		184
4. Meat specialties	1	6	15	3		7	6		14		441
5. Soups and baby foods		2	3		1		3		2		124
6. Tomato - cheese-starch comb.		12	1			2	1				89
7. Sauced vegetables		5	5	1	1	1	36		7		230
8. Sweet syrups, jams & jellies		2	2			4			4		82
9. Chinese & Mexican foods		4	6	1	1	2	4		1		202
10. Breaded frozen products		5	20	1		20	35		17		505
TOTAL	1	49	77	10	5	45	100		59		2,321

SECTION VII

APPENDICES

APPENDIX A

FIELD INVESTIGATION REPORTS

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Plant C - Prepared Dinners, Category 1	59
Plant D - Prepared Dinners, Category 1	62
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Plant S - Sauced Vegetables, Category 7 105

Plant T - Sweet Syrups, Category 8 109

Plant U - James and Jellies, Category 8 113

Plant V - Chinese Foods, Category 9 116

Plant W - Chinese Foods, Category 9 119

Plant X - Mexican Foods, Category 9 122

Plant Y - Breaded Frozen Products, Category 10 126

Plant Z - Breaded Fish and Shellfish, Category 10 129

PREPARED DINNERS

- Plant Code: A
- Location: East
- Category: 1
- Products: Prepared dinners, meat entrees, bakery desserts

Dinners: beef, meat loaf, salisbury steak, ham, spaghetti and meatballs, franks and beans, macaroni and beef, macaroni and cheese, beef enchaladas, chicken, turkey, fish, shrimp, tuna.
Pot Pies: beef, chicken, turkey, tuna.
Bakery Products: pies, cakes, toppings, pastries.

- Significant Ingredients (used during sampling period)

Processed at Plant	Pre-Processed Elsewhere		
Gravies	All vegetables		
Poultry (cutting, deboning, frying, or boiling)	Poultry (initial cleaning and slaughtering)		
	Beef	Shortening	Eggs
	Flour	Flavorings	Fruits
	Milk	Chocolate	Sugar

- Sampling Procedure

An automatic sampler was used to collect ten 24-hour time interval composite samples of the raw plant wastewater.

The samples were taken just downstream from the 20 mesh screening operation.

- Wastewater Characteristics

Combined Process and Clean-Up Wastewater
(24 Hour Composites)*

	COD	BOD	SS	VSS	Total P	TKN	Grease & Oil
Avg. Conc. (mg/l)	7,900	4,000	3,900	3,800	29	51	5,100
Range of Conc. (mg/l)	3,900-17,000	2,000-6,500	1,700-8,300	1,700-8,300	20-41	14-82	2,200-9,900

*Ten samples
pH range - 4.7-10.0

- Productivity Factors

Based upon average daily wastewater volumes, production data supplied by the plant, and wastewater quality characteristics from lab analysis, the following productivity factors were calculated.

PRODUCTIVITY FACTORS
Combined Process and Clean-Up Wastewaters

Constituent	Average kg/kkg Finished Product
COD	69
BOD	35
SS	34
VSS	33
Total P	0.25
TKN	0.44
Grease & Oil	44
Wastewater Generation (l/kkg finished product)	8,700

1 lb/ton = 0.5 kg/kkg
1 gallon/ton = 4.173 l/kkg

- Treatment facilities

Treatment facilities at this specialty food plant are extensive as shown on Figure A-1 and include the following operations:

- Rotary screening
- Gravity sedimentation
- Dissolved air flotation
- Anaerobic lagooning
- Biological trickling filtration
- Aeration
- Final clarification
- Chlorination

This unit processes chain is reported to consistently produce an effluent of less than 20 mg/l BOD starting with a raw waste of 3,000 to 4,000 mg/l BOD. Grease and oil is reduced to about 2 mg/l and suspended solids to less than 40 mg/l. According to the operators, the key treatment units are the anaerobic lagoons which stabilize the waste and equalize the flow into the trickling filters.

A tabulation of reported unit reductions of screened wastes in BOD, G&O, and SS follows:

	Percent Reduction		
	BOD	G&O	SS
Sedimentation	40	80	73
Flotation	15	14	16
Anaerobic lagoon	4	6	7
Trickling filter	15	-	(3)
Activated sludge	26	-	6
Total	100	100	99

This treatment facility evolved over a ten year period and is not suggested as an optimum design for a new facility. The final effluent is discharged to a small creek and is the only water source into the creek most of the year.

Design data for the waste treatment plant shown in Figure A-1 is as follows:

Design Flow: Approximately 0.5 MGD.

Screens: Two 20 mesh Sweco screens remove approximately 1,000 lbs/day of screened solids which are disposed to landfills.

Sedimentation Tanks: Two rectangular clarifiers, 10 ft x 125 ft x 10 ft, 187,000 gal. capacity.

Dissolved Air Flotation Tanks: Two rectangular tanks, 200 sq ft surface area each.

Anaerobic Lagoons: Three lagoons, 1.93 million gal. capacity each, with approximately 100 percent recirculation from final lagoon to first lagoon.

Trickling Filters: 5,500 cu ft plastic media and 11,000 cu ft rock media in series.

Activated Sludge Aeration Tanks: Four rectangular tanks, each 141,000 gal capacity, with mechanical aerators.

Final clarifiers: Two circular clarifiers with 962 sq ft and 1,590 sq ft surface area respectively. Activated sludge recirculation rate is approximately 50 percent.

Primary Sludge and Waste Activated Sludge is centrifuged, thickened and disposed to landfill. Approximately 4,500 lbs per day of grease is recovered and sold for 2-1/2 ¢/lb.

Chlorine Contact Tank: Provides 0.5 hours contact time.

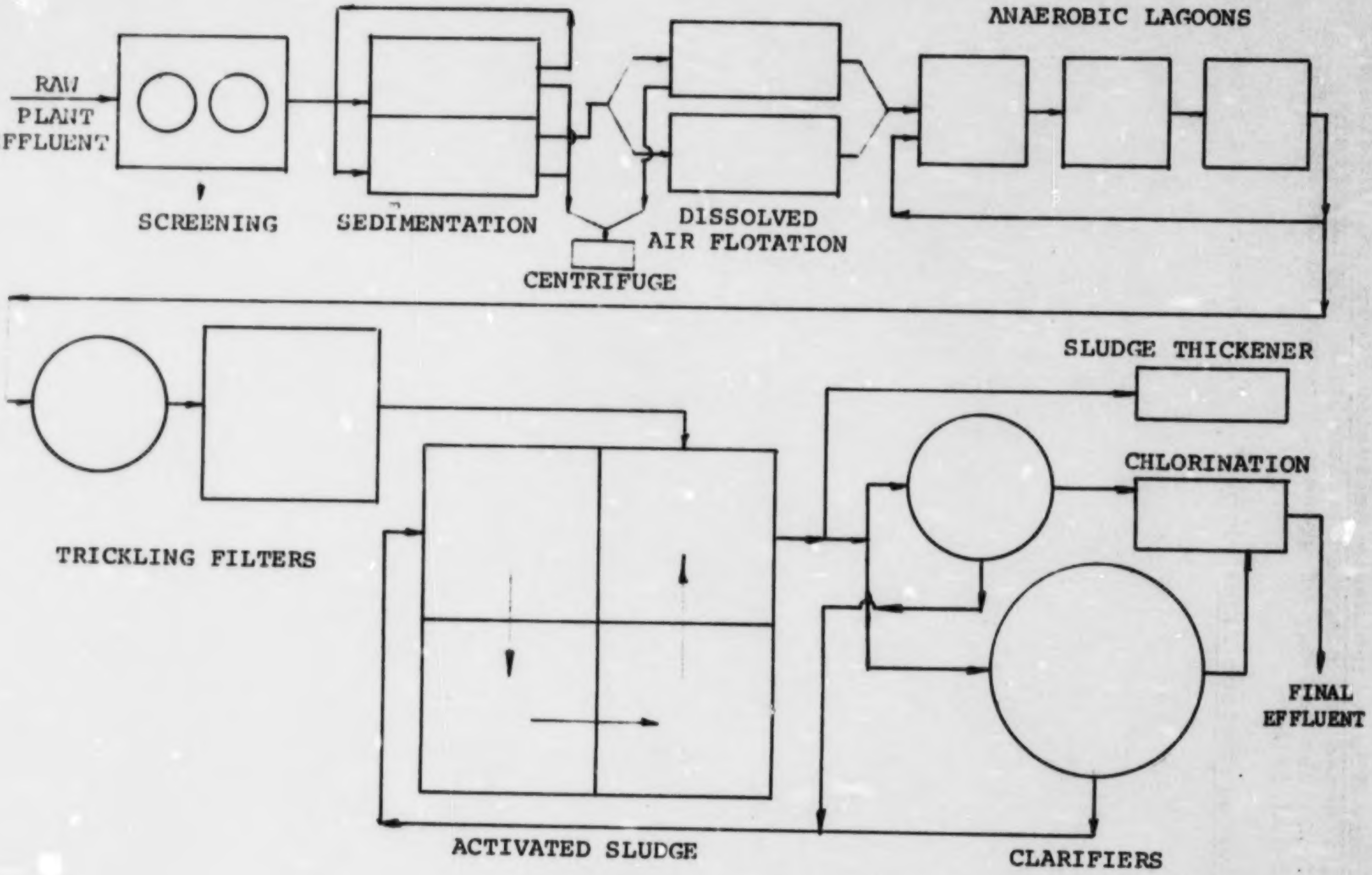

ANAEROBIC LAGOONS
RAW
PLANT EFFLUENT
SCREENING
SEDIMENTATION
DISSOLVED AIR FLOTATION
CENTRIFUGE
SLUDGE THICKENER
CHLORINATION
TRICKLING FILTERS
FINAL EFFLUENT
ACTIVATED SLUDGE
CLARIFIERS

FIGURE A-1

PLANT A
WASTEWATEF TREATMENT FACILITY

PREPARED DINNERS

- Plant Code: B
- Location: West
- Category: 1
- Products: Prepared dinners and pot pies

Entrees: sliced turkey, fried chicken, meat loaf, roast beef, beef enchiladas, cheese enchiladas.
Other Ingredients: potatoes, rice, corn, peas, beans.

- Significant Ingredients (used during sampling period)

Processed at Plant	Pre-Processed Elsewhere	
Gravies	All vegetables	
Beans	Poultry (initial slaughtering and cleaning)	
Turkey (deboned, cooked, sliced)	Beef	Olives
Chicken (cut, fried or deboned, boiled)	Rice	Flour
	Cheese	Milk

A simplified schematic diagram of plant operations is shown in Figure A-2.

- Sampling Procedure

An automatic sampler was used to collect two time interval composite samples per day of the raw waste at the inlet to the pre-treatment flotation tank. Five samples of the basic production operation (6:30 a.m.-4:30 p.m.), and five samples of the general cleanup and ingredient preparation activities (4:30 p.m.-6:30 a.m.) were taken.

- Wastewater Characteristics

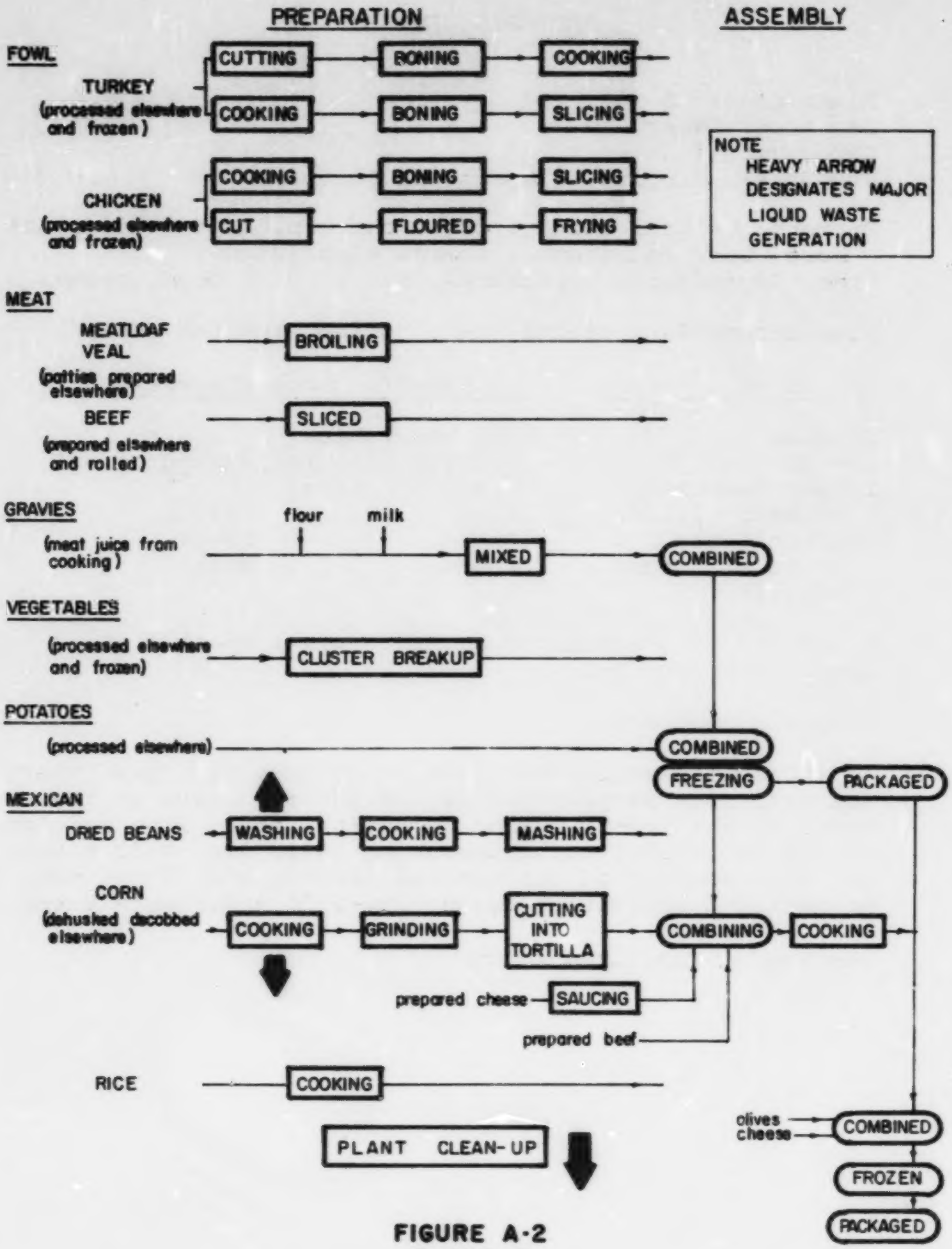

PREPARATION
ASSEMBLY
FOWL
TURKEY (processed elsewhere and frozen)
CUTTING
BONING
COOKING
COOKING
BONING
SLICING
CHICKEN (processed elsewhere and frozen)
COOKING
BONING
SLICING
CUT
FLOURED
FRYING
NOTE HEAVY ARROW DESIGNATES MAJOR LIQUID WASTE GENERATION
MEAT
MEATLOAF
VEAL
(patties prepared elsewhere)
BROILING
BEEF (prepared elsewhere and rolled)
SLICED
GRAVIES
(meat juice from cooking)
flour
milk
MIXED
COMBINED
VEGETABLES
(processed elsewhere and frozen)
CLUSTER BREAKUP
POTATOES
(processed elsewhere)
COMBINED
FREEZING
PACKAGED
MEXICAN
DRIED BEANS
WASHING
COOKING
MASHING
CORN (dehusked decobbed elsewhere)
COOKING
GRINDING
CUTTING INTO TORTILLA
COMBINING
COOKING
prepared cheese
SAUCING
prepared beef
RICE
COOKING
PLANT CLEAN-UP
olives
cheese
COMBINED
FROZEN
PACKAGED

FIGURE A-2
PLANT B
PREPARED DINNER PLANT
SIMPLIFIED PROCESS FLOW DIAGRAM

Production Shift Wastewater*
(6:30 a.m. - 4:30 p.m.)

	COD	BOD	SS	VSS	Total P	TKN	Grease & Oil
Avg. Conc. (mg/l)	12,000	4,800	2,700	2,700	16	44	7,800
Range of Conc. (mg/l)	6,400-20,000	3,200-8,600	1,800-3,400	1,800-3,400	10-30	1.9-62	5,600-10,000

*Five samples
pH range - 5.2-6.1

Clean-Up and Gravy Preparation Shift Wastewater*
(4:30 p.m. - 6:30 a.m.)

	COD	BOD	pH	SS	VSS	Total P	TKN
Avg. Conc. (mg/l)	3,100	1,500		1,100	1,100	39	27
Range of Conc. (mg/l)	1,800-6,800	570-3,000	6.3-6.8	630-2,200	620-2,200	28-60	21-45

*Five samples

- Productivity Factors

  Based upon wastewater volumes and production figures provided during the 10 sampling periods, productivity factors were calculated for (1) the total 24 hours, (2) the production shift, and (3) the clean-up and gravy preparation shift. The results are shown on the following three tables.

PRODUCTIVITY FACTORS
Combined Process and Clean-Up Wastewaters

Constituent	Average kg/kkg finished product	Range kg/kkg finished product
COD	42	25-82
BOD	18	10-39
SS	11	7.0-17
VSS	11	6.9-17
Total P	0.18	0.16-0.24
TKN	0.25	0.08-0.30
Grease & Oil*	21	14-29
Wastewater Generation (l/kkg finished product)	6,200	6,100-6,400

*Data available for production shift only.

PRODUCTIVITY FACTORS
Production Shift Wastewater
(6:30 a.m. - 4:30 p.m.)

Constituent	Average kg/kkg finished product*	Range kg/kkg finished product*
COD	45	22-83
BOD	27	11-51
SS	10	6.6-14
VSS	10	6.6-14
Total P	0.060	0.042-0.12
TKN	0.16	0-0.21
Grease & Oil	31	20-42
Wastewater Generation (l/kkg finished product)	3,600	3,500-4,200

*Average during designated time period.

PRODUCTIVITY FACTORS
Clean-Up and Gravy Preparation Wastewater
(4:30 p.m. - 6:30 a.m.)

Constituent	Average kg/kkg finished product*	Range kg/kkg finished product*
COD	37	26-78
BOD	18	7.1-34
SS	13	7.9-25
VSS	12	7.7-25
Total P	0.46	0.35-0.69
TKN	0.32	0.26-0.51
Wastewater Generation (l/kkg finished product)	12,000	11,000-13,000

*Average during designated time period.

1 lb/ton = 0.5 k/kkg
1 gallon/ton = 4.173 l/kkg

Approximately 70 percent of the plant production occurs during what is called the "Production Shift," while 30 percent occurs during the "Clean-Up Shift." The tables show that the general clean-up period at this plant generates approximately 60 percent of the total daily flow volume.

- Pre-Treatment Facilities

Pre-treatment prior to discharge to the city sewers consists of pressurized dissolved air flotation, coagulation and settling for removal of grease, flotables, and suspended solids.

PREPARED DINNERS

- Plant Code: C
- Location: West
- Category: 1
- Products: Prepared dinners and pot pies

Entrees: macaroni and cheese, macaroni and beef, sliced turkey, fried chicken, beans and franks, swiss steak, meat loaf, chopped beef sirloin, pork loin, veal parmigiana, chow mein, beef enchiladas, tamales, sweet'n sour chicken and pork.
Other Ingredients: carrots, corn, peas, green beans, refried beans, rice, potatoes, apples, desserts.
Pot Pies: beef, turkey, chicken.

- Significant Ingredients (used during sampling period)

Processed at Plant	Pre-Processed Elsewhere	
Beans	All vegetables	Rice
Gravies	All fruit	Flour
	Macaroni	Milk
	Beef	Cheese
	Turkey	Sauces
	Chicken	Chocolate
	Pork	Eggs
	Potatoes	

A simplified schematic diagram of plant operations is shown in Figure A-3.

- Sampling Procedure

An automatic sampler was used to collect eight 24-hour time interval composite samples of the raw plant wastewater at the inlet to the settling tank.

- Wastewater Characteristics

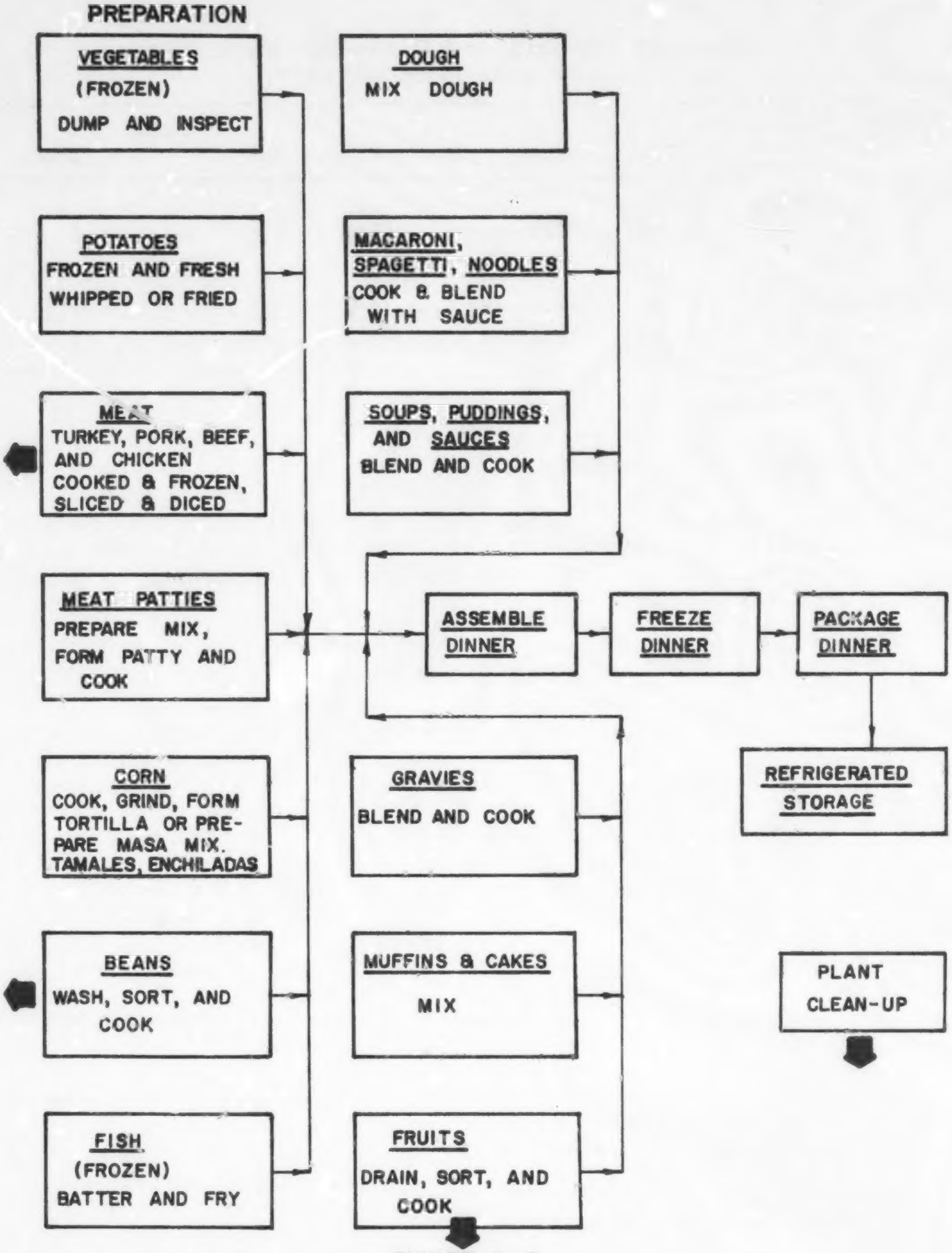

PREPARATION
VEGETABLES (FROZEN) DUMP AND INSPECT
DOUGH MIX DOUGH
POTATOES FROZEN AND FRESH WHIPPED OR FRIED
MACARONI, SPAGETTI, NOODLES COOK & BLEND WITH SAUCE
MEAT TURKEY, PORK, BEEF, AND CHICKEN COOKED & FROZEN, SLICED & DICED
SOUPS, PUDDINGS, AND SAUCES BLEND AND COOK
MEAT PATTIES PREPARE MIX, FORM PATTY AND COOK
ASSEMBLE DINNER
FREEZE DINNER
PACKAGE DINNER
REFRIGERATED STORAGE
CORN COOK, GRIND, FORM TORTILLA OR PREPARE MASA MIX. TAMALES, ENCHILADAS
GRAVIES BLEND AND COOK
BEANS WASH, SORT, AND COOK
MUFFINS & CAKES MIX
PLANT CLEAN-UP
FISH (FROZEN) BATTER AND FRY
FRUITS DRAIN, SORT, AND COOK

FIGURE A-3
PLANT C
PREPARED DINNER PLANT
SIMPLIFIED PROCESS FLOW DIAGRAM
(HEAVY ARROWS DESIGNATE MAJOR WASTEWATER GENERATING OPERATIONS)

Combined Process and Clean-Up Wastewater
(24 Hour Composites)*

	COD	BOD	pH	SS	VSS	Total P	TKN
Avg. Conc. (mg/l)	1,300	620		530	510	11	28
Range of Conc. (mg/l)	850-2,400	490-920	6.3-7.2	330-650	320-640	9.3-14	7.3-43

*Eight samples

- Productivity Factors

Based upon daily wastewater volumes, production data supplied by the plant, and wastewater quality characteristics from the lab, the following productivity factors were calculated.

PRODUCTIVITY FACTORS
Combined Process and Clean-Up Wastewaters

Constituent	Average kg/kkg finished product	Range kg/kkg finished product
COD	28	19-55
BOD	13	9.2-18
SS	11	8.8-14
VSS	11	8.5-14
Total P	0.24	0.17-0.33
TKN	0.61	0.16-0.93
Wastewater Generation (l/kkg finished product)	22,000	18,000-27,000

1 lb/ton = 0.5 kg/kkg
1 gallon/ton = 4.173 l/kkg

- Pre-Treatment Facilities

Pre-treatment consists of settling followed by 20 mesh rotary screening for removal of solids and BOD. The effluent is then discharged to the sewer.

PREPARED DINNERS

- Plant Code: D
- Location: East
- Category: 1
- Products: Prepared institutional dinners

Entrees: meat loaf, choppen sirloin, swiss steak, chicken fricassee, stuffed peppers, fish.
Other Ingredients: creamed spinach, peas, beans, corn, other vegetables, potatoes.

- Significant Ingredients (used during sampling period)

Processed at Plant	Pre-Processed Elsewhere	
Spinach	Beef (initial butchering)	
Bell peppers	Chicken (initial cleaning)	
Beef (cooking only)	Fish	Butter
Chicken (cutting, deboning, cooking)	Rice	Potatoes
	Milk	Seasonings

A simplified schematic diagram of plant operations is shown in Figure A-4.

- Sampling Procedure

An automatic sampler was used to take eight 24-hour, time interval composite samples of the raw wastewater at the inlet to the settling tank.

- Wastewater Characteristics

Combined Process and Clean-Up Wastewater
(24 Hour Composite)*

	COD	BOD	SS	VSS	Total P	TKN	Grease & Oil
Avg. Conc. (mg/l)	1,300	720	680	650	7.6	26	140-
Range of Conc. (mg/l)	790-2,600	200-1,500	420-1,400	380-1,400	3.5-12	12-59	120-200

*Eight samples
pH range - 4.4-7.1

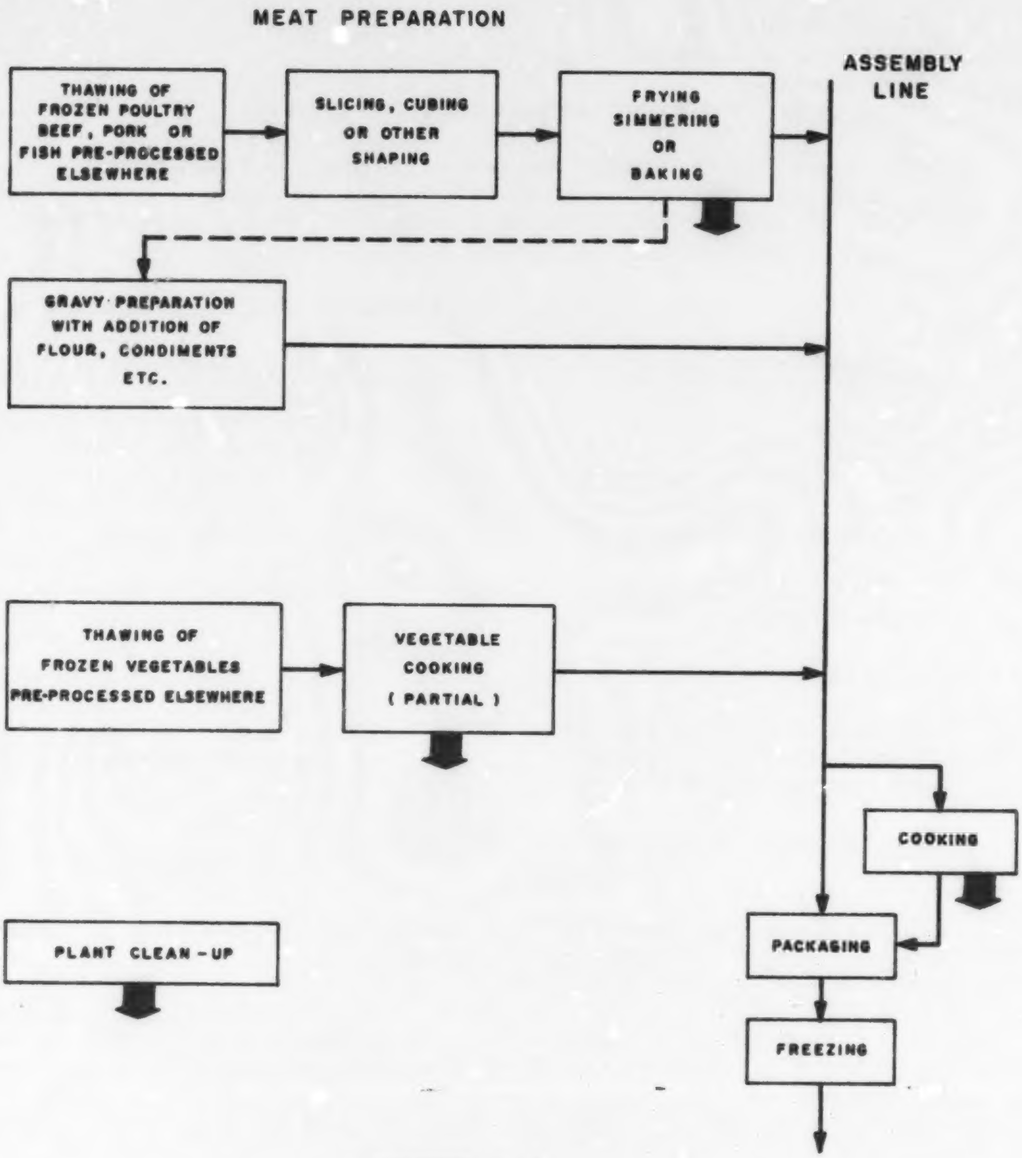

MEAT PREPARATION
ASSEMBLY LINE
THAWING OF FROZEN POULTRY BEEF, PORK OR FISH PRE-PROCESSED ELSEWHERE
SLICING, CUBING OR OTHER SHAPING
FRYING SIMMERING OR BAKING
GRAVY PREPARATION WITH ADDITION OF FLOUR, CONDIMENTS ETC.
THAWING OF FROZEN VEGETABLES PRE-PROCESSED ELSEWHERE
VEGETABLE COOKING (PARTIAL)
COOKING
PLANT CLEAN - UP
PACKAGING
FREEZING

FIGURE A-4

PLANT D

PREPARED DINNER PLANT

SIMPLIFIED PROCESS FLOW DIAGRAM
(heavy arrows designate major
wastewater generating operations)

- **Productivity Factors**

  Based upon average, daily wastewater volumes, production data supplied by the plant, and wastewater quality characteristics from laboratory analyses, the following productivity factors were generated.

PRODUCTIVITY FACTORS
Combined Process and
Clean-Up Wastewaters

Constituent	Average kg/kkg finished products
COD	27
BOD	15
SS	14
VSS	14
Total P	0.16
TKN	0.55
Grease & Oil	2.9
Wastewater Generation (l/kkg finished product)	21,000

1 lb/ton = 0.5 kg/kkg
1 gallon/ton = 4.173 l/kkg

- Treatment Facilities

  Wastewater treatment includes settling for solids removal and land disposal by spraying into a wooded area.

PREPARED DINNERS, VEGETABLES

- Plant Code: E (Historical Data Only)
- Location: Midwest
- Category: 1
- Products: Prepared dinners, vegetables

Entrees: tuna noodle casserole, potatoes au gratin, lasagna, creamed chipped beef, spinach souffle, macaroni and cheese, macaroni and beef.

- Significant Ingredients (used during sampling period)

Processed at Plant	Pre-Processed Elsewhere	
Beef (cutting, cooking)	Beef (initial butchering)	
	Tuna	Cheese
	Potatoes	Milk
	Noodles	Flour
	Vegetables	Butter

- Sampling Procedure

Three composite samples were obtained for the tests, each representing four hours of operation on a different day. Each sample consisted of a composite of grab samples taken at five minute intervals over a period of four hours. A composite total of five gallons was obtained during each sampling period.

All samples were taken from the combined waste manhole, on the plant property. The samples were taken in such a manner as to insure collection of representative portions of solids and floating material. The samples were refrigerated during the collection period and while in-transit to the laboratory.

- Wastewater Characteristics

Combined Process and Clean-Up Wastewater
(24 Hour Composites)*

	COD	BOD	pH	SS	VSS	Grease & Oil
Avg. Conc. (mg/l)	2,100	1,200		700	640	400
Range of Conc. (mg/l)	1,700- 2,400	1,000- 1,500	8.3- 9.1	380- 1,100	360- 1,000	200- 800

*Three samples

- Productivity Factors

  Based upon daily wastewater volumes, production data supplied by the plant, and wastewater quality characteristics from lab analysis, the following productivity factors were calculated.

PRODUCTIVITY FACTORS
Combined Process and
Clean-Up Wastewaters

Constituent	kg/kkg finished product
COD	20
BOD	11
SS	6.6
VSS	6.0
Grease & Oil	3.8
Wastewater Generation (l/kkg finished product)	9,400 l/kkg

1 lb/ton = 0.5 kg/kkg
1 gallon/ton = 4.173 l/kkg

- Pre-Treatment Facilities

  Collection baskets are used in the trench drains to collect solids such as macaroni and potatoes, before the wastewater enters the sewer. No other pre-treatment is provided.

PREPARED DINNERS

- Plant Code: F
- Location: East
- Category: 1
- Products: Prepared dinners, pot pies, stews and other meat entree dishes

Dinners: beef, chicken, pork, turkey.
Pies: beef, chicken, turkey.
Stews: beef, brunswick, lamb, chicken, mixed.
Miscellaneous: stuffed peppers, stuffed cabbage, beef gravy, chicken and gravy, chicken and noodles, chicken (boned), chili con carne, hamburgers, meat balls, salisbury steak, turkey with gravy, veal parmigiana, shrimp creole, lasagne, macaroni, spaghetti.

- Significant Ingredients

Processed at Plant	Pre-Processed Elsewhere	
Gravies	All vegetables	
Noodles	Beef	Shrimp
	Turkey	Flour
	Chicken	Milk
	Pork	Seasonings
	Lamb	Tomatoes

- Sampling Procedure

An automatic sampler was used to collect seven 24-hour, time interval composite samples of the raw plant wastewater. The samples were taken just downstream from a preliminary screening operation at the inlet to the wastewater treatment facility.

- Wastewater Characteristics

Combined Process and Clean-Up Wastewaters
(24 Hour Composites)*

	COD	BOD	SS	VSS	Total P	TKN	Grease & Oil
Avg. Conc. (mg/l)	3,800	2,000	1,400	1,400	28	85	1,100
Range of Conc. (mg/l)	1,700-8,200	1,200-4,700	460-3,000	440-2,900	22-41	55-100	230-2,900

*Seven samples
pH range: 5.7-9.8

- Productivity Factors

Based upon average daily wastewater volumes, production data supplied by the plant, and wastewater quality characteristics, the following productivity factors were calculated.

PRODUCTIVITY FACTORS
Combined Process and
Clean-Up Wastewaters

Constituent	Average kg/kkg finished product
COD	17
BOD	8.8
SS	6.2
VSS	6.2
Total P	0.12
TKN	0.37
Grease & Oil	4.8
Wastewater Generation (l/kkg finished product)	4,400

1 lb/ton = 0.5 kg/kkg
1 gallon/ton = 4.173 l/kkg

- Treatment Facilities

The wastewater treatment facility at the plant is quite extensive and includes the following operations:

- primary settling
- grease removal
- air flotation
- aerated lagooning (8 day retention time)
- final clarification
- sand filtration
- chlorination

The treated effluent is discharged to a nearby creek.

FROZEN BAKERY PRODUCTS

- Plant Code: G
- Location: Midwest
- Category: 2
- Products: Complete assortment of frozen bakery products

  Bakery Items: cakes, pies, rolls, pastries, cookies.

- Significant Ingredients (used during sampling period)

Processed at Plant	Pre-Processed Elsewhere	
None	Flour	Chocolate
	Butter	Milk
	Shortening	Eggs
	Sugar	Flavorings
	Fruits	Salt

A simplified schematic diagram of plant operations is shown in Figure A-5.

- Sampling Procedure

  An automatic sampler was used to collect ten 24-hour, time interval composite samples of the raw wastewater at the surge tank immediately preceding the pre-treatment unit.

- Wastewater Characteristics

Combined Process and Clean-Up Wastewater
(24 Hour Composites)*

	COD	BOD	SS	VSS	Total P	TKN	Grease & Oil
Avg. Conc. (mg/l)	4,600	2,100	1,300	1,200	7.8	27	940
Range of Conc. (mg/l)	3,000-6,000	1,700-2,400	730-1,600	710-1,500	4.1-12	14-42	500-1,500

*Ten samples
pH range: 4.5-6.2

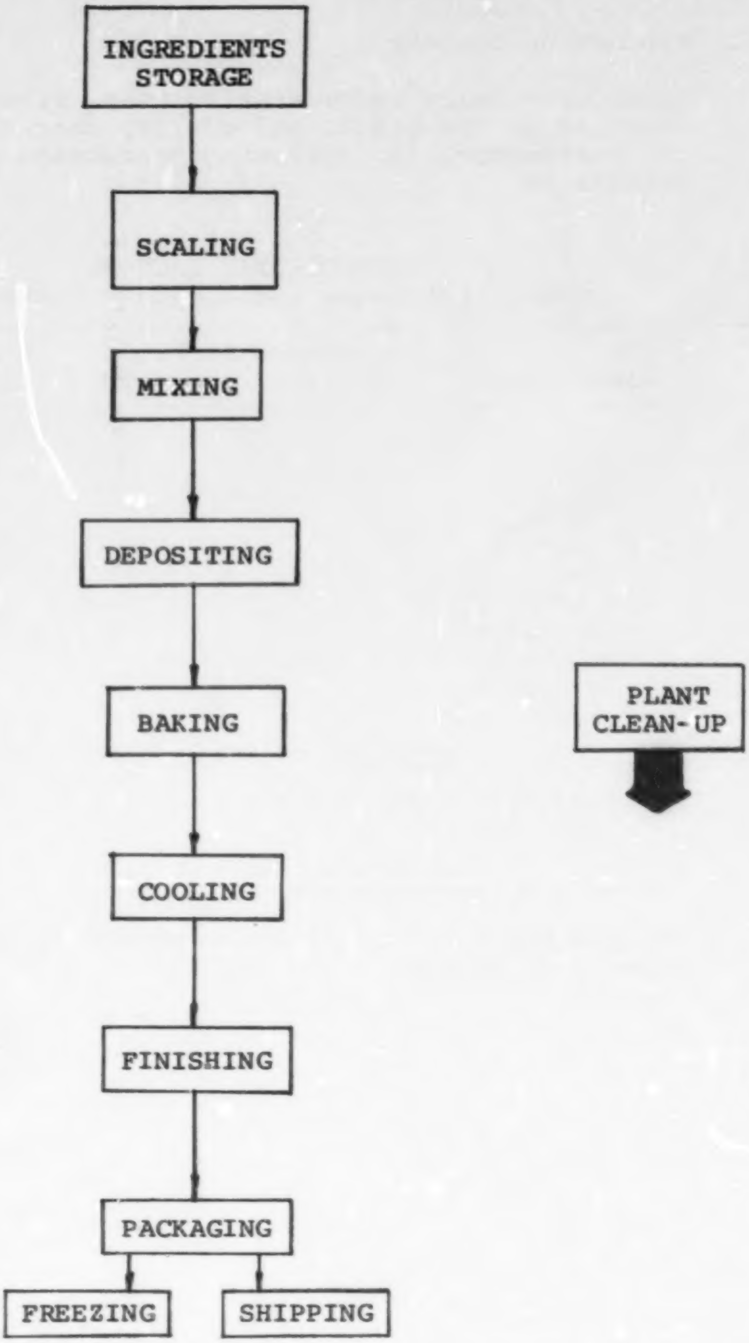

INGREDIENTS STORAGE
SCALING
MIXING
DEPOSITING
BAKING
COOLING
FINISHING
PACKAGING
FREEZING
SHIPPING
PLANT CLEAN-UP

FIGURE A-5

PLANT G
FROZEN BAKERY PRODUCTS PLANT
SIMPLIFIED PROCESS FLOW DIAGRAM
(heavy arrow designates major wastewater generating operations)

- Production Factors

Based upon daily wastewater volumes, production data supplied by the plant, and quality characteristics of the wastewater, the following production factors were calculated.

PRODUCTIVITY FACTORS
Combined Process and Clean-Up Wastewaters

Constituent	Average kg/kkg finished product	Range kg/kkg finished product
COD	52	31-83
BOD	23	17-29
SS	14	7.5-21
VSS	14	7.3-20
Total P	0.082	0.045-0.11
TKN	0.30	0.15-0.59
Grease & Oil	11	5.2-15
Wastewater Generation (l/kkg finished product)	11,000	

1 lb/ton = 0.5 kg/kkg
1 gallon/ton = 4.173 l/kkg

- Pre-Treatment Facilities

Pre-treatment at the bakery consists of settling for removal of solids.

FROZEN BAKERY PRODUCTS

- Plant Code: H
- Location: Midwest
- Category: 2
- Products: Complete assortment of frozen bakery products

Bakery items: pies, cakes, pastries, rolls, bread.

- Significant Ingredients

Processed at Plant	Pre-Processed Elsewhere	
None	Flour	Fruits
	Milk	Chocolate
	Eggs	Flavorings
	Butter	Spices
	Shortening	Nuts
	Oil	Sugar

- Sampling Procedure

An automatic sampler was used to collect eight daily, time interval composite samples of the raw wastewater at the inlet to the wastewater treatment facility.

- Wastewater Characteristics

Combined Processing and Clean-Up Wastewater
(7 a.m. - 11:30 p.m.)*

	COD	BOD	SS	VSS	Total P	TKN	Grease & Oil
Avg. Conc. (mg/l)	9,300	4,300	3,071	2,991	5.7	44.7	688
Range of Conc. (mg/l)	4,600-23,000	2,700-8,000	800-12,000	780-12,000	2.1-12	3.2-83	350-1,400

*Eight samples
ph range: 4.3-5.7

- Productivity Factors

This plant was the only one investigated that did not cooperate in supplying production data. Thus no wastewater productivity factors could be calculated.

- Pre-Treatment Facilities

  Pre-treatment at this bakery consists of activated sludge and clarification for removal of BOD and solids. The effluent is discharged to the city sewer.

SALAD DRESSINGS AND OILS

- Plant Code: I
- Location: West
- Category: 3
- Products: Sauces, dressings, and oils

Barbecue sauces, shortening, margarine and vegetable oil, jellies and toppings, drink bases, processed cheese, marshmellows, mustard.

- Significant Ingredients (used during sampling period)

Processed at Plant	Pre-Processed Elsewhere	
Mustard seed	Vegetable oil	Vinegar
Marshmellows	Fruits	Salt
	Chocolate	Sugar
	Cheese	Seasonings
	Milk	Spices

A simplified schematic diagram of plant operations is shown in Figure A-6.

- Sampling Procedure

Ten 24-hour time interval composite samples of the raw plant wastewater were taken by plant personnel. The samples were collected at the inlet to the plant wastewater treatment facility.

- Watewater Characteristics

Combined Process and Clean-Up Wastewaters
(24 Hour Composites)*

	COD	BOD	SS	VSS	Total P	TKN	Grease & Oil
Avg. Conc. (mg/l)	4,900	2,300	1,000	960	16	15	1,300
Range of Conc. (mg/l)	3,200- 8,400	1,100- 4,000	420- 1,400	420- 1,300	2.3- 24	8.1- 33	1,100- 1,300

*Ten samples
pH range: 6.1-9.0

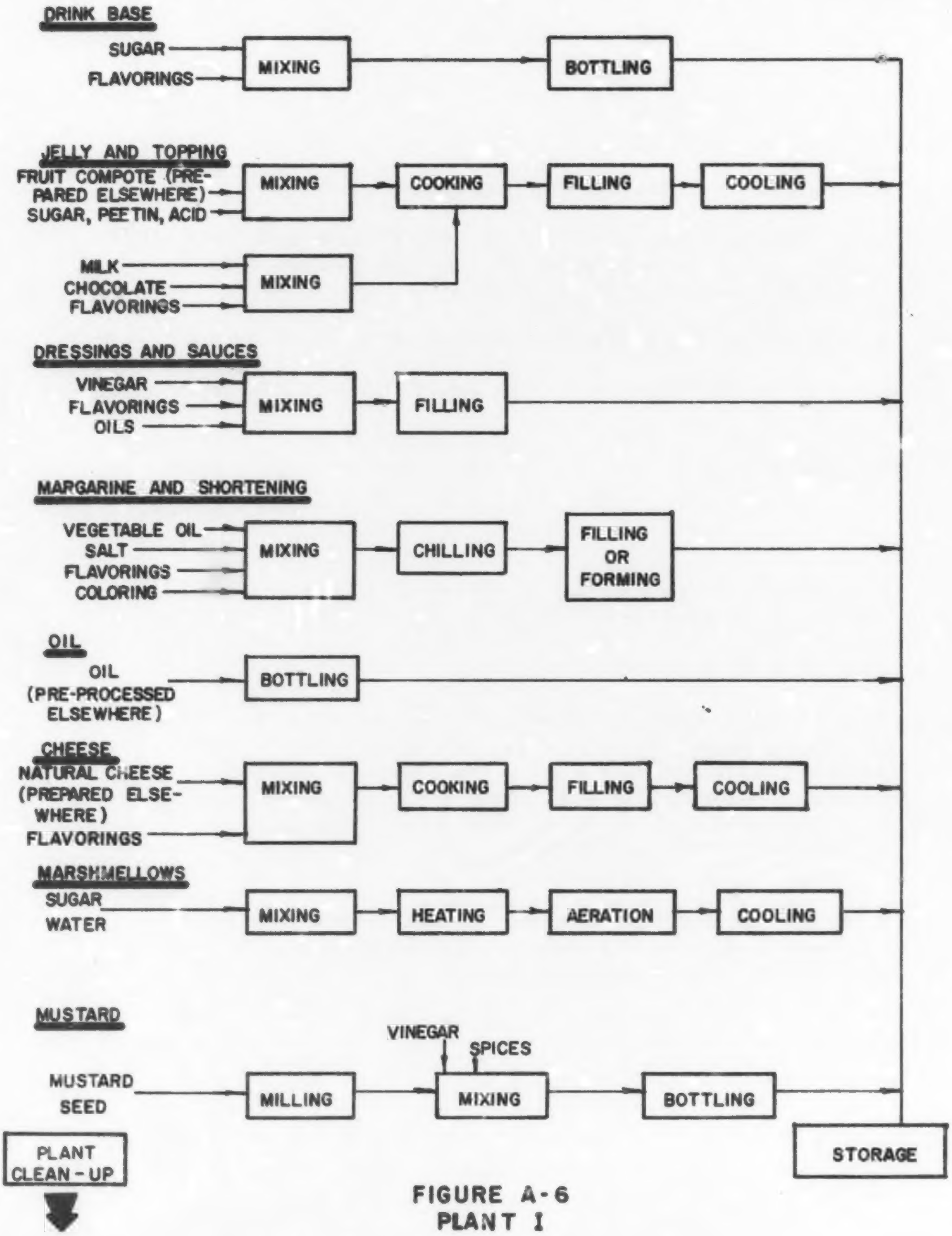

DRINK BASE
SUGAR
FLAVORINGS
MIXING
BOTTLING
JELLY AND TOPPING
FRUIT COMPOTE (PRE-PARED ELSEWHERE)
SUGAR, PEETIN, ACID
MIXING
COOKING
FILLING
COOLING
MILK
CHOCOLATE
FLAVORINGS
MIXING
DRESSINGS AND SAUCES
VINEGAR
FLAVORINGS
OILS
MIXING
FILLING
MARGARINE AND SHORTENING
VEGETABLE OIL
SALT
FLAVORINGS
COLORING
MIXING
CHILLING
FILLING OR FORMING
OIL
OIL (PRE-PROCESSED ELSEWHERE)
BOTTLING
CHEESE
NATURAL CHEESE (PREPARED ELSE-WHERE)
FLAVORINGS
MIXING
COOKING
FILLING
COOLING
MARSHMELLOWS
SUGAR
WATER
MIXING
HEATING
AERATION
COOLING
MUSTARD
MUSTARD SEED
MILLING
VINEGAR
SPICES
MIXING
BOTTLING
PLANT CLEAN-UP
STORAGE

FIGURE A-6
PLANT I

SALAD DRESSING & SAUCE PLANT
SIMPLIFIED PROCESS FLOW DIAGRAM
(HEAVY ARROW DESIGNATES MAJOR WASTEWATER PRODUCING OPERATION)

- Productivity Factors

Based on daily metered wastewater flows, wastewater quality characteristics, and production data supplied by the plant, the following productivity factors were calculated.

PRODUCTIVITY FACTORS
Combined Process and Clean-Up Wastewaters

Constituent	Average kg/kkg finished product	Range kg/kkg finished product
COD	12	5.4-20
BOD	5.6	2.4-9.0
SS	2.6	1.0-3.7
VSS	2.4	1.0-3.1
Total P	0.039	0.010-0.067
TKN	0.036	0.019-0.069
Grease & Oil	3.1	1.9-3.9
Wastewater Generation (l/kkg finished product)	2,600	1,800-3,200

1 lb/ton = 0.5 kg/kkg
1 gallon/ton = 4.173 l/kkg

- Pre-Treatment Facilities

Wastewater pre-treatment at this food plant consists of gravity settling for solids removal and skimming for removal of grease and floatables.

The final effluent is discharged to the municipal sewer.

DRESSINGS, SAUCES, AND PIE FILLINGS

- Plant Code: J
- Location: Northern California
- Category: 3
- Products: Dressings, sauces and pie fillings

Dressings: bleu cheese, French, green goddess, Italian, thousand island, mayonnaise, cole slaw.
Sauces: taco, tarter, barbecue.

- Significant Ingredients (used during sampling period)

Processed at Plant	Pre-Processed Elsewhere	
None	Worchestershire sauce	
	Seasonings	Oil
	Red pepper	Salt
	Tomatoes	Cheeses
	Vinegar	

A simplified schematic diagram of plant operations is shown in Figure A-7.

- Sampling Procedure

An automatic sampler was used to collect ten time interval composite samples of the raw wastewater from the surge tank proceeding discharge to the sewer.

Five samples of the process shift (8:00 a.m.-4:00 p.m.) and five samples of the clean-up shift (4:00 p.m.-12 midnight) were taken.

- Wastewater Characteristics

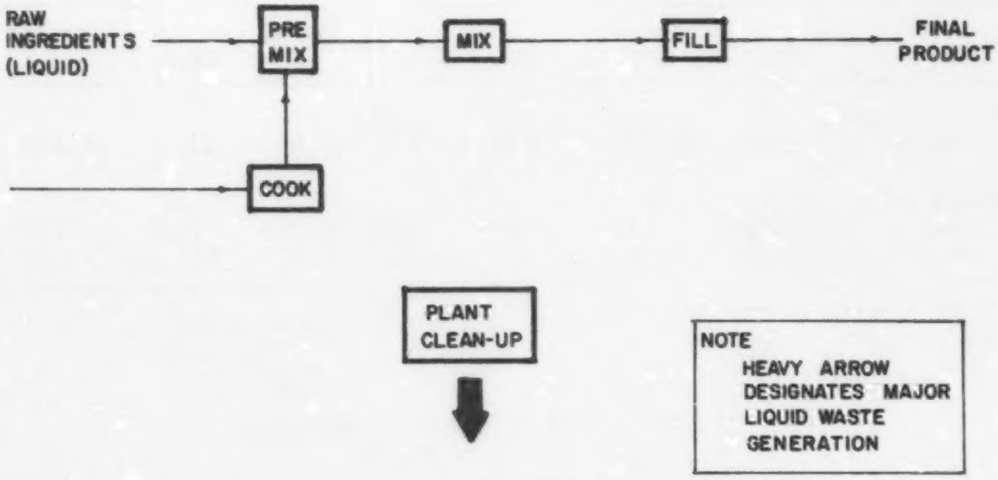

RAW INGREDIENTS (LIQUID)
PRE MIX
MIX
FILL
FINAL PRODUCT
COOK
PLANT CLEAN-UP
NOTE
HEAVY ARROW DESIGNATES MAJOR LIQUID WASTE GENERATION

FIGURE A-7
PLANT J

SALAD DRESSING PLANT
SIMPLIFIED PROCESS FLOW DIAGRAM

Process Shift Wastewater*
(8 a.m. - 4 p.m.)

	COD	BOD	SS	VSS	Total P	TKN	Grease & Oil
Avg. Conc. (mg/l)	3,100	2,000	880	870	2.0	11	2,100
Range of Conc. (mg/l)	1,200- 4,500	750- 3,000	430- 1,300	420- 1,200	0.25- 5.4	2.2- 19	930- 3,900

*Five samples
pH range: 4.2-4.9

Clean-Up Shift Wastewater*
(4 p.m. - 12 midnite)

	COD	BOD	SS	VSS	Total P	TKN	Grease & Oil
Avg. Conc. (mg/l)	5,700	4,000	1,900	1,900	9.2	14	3,200
Range of Conc. (mg/l)	4,100- 7,500	2,800- 5,200	1,400- 2,500	1,400- 2,500	6.9- 12	2.9- 28	2,100- 4,900

*Five samples
pH range: 6.1-9.3

- Productivity Factors

Based upon average wastewater volumes generated during the process and clean-up shifts, quality characteristics of the wastewater, and production data supplied by the plant, the following production factors were calculated for the process shift, the clean-up shift, and the total effluent.

PRODUCTIVITY FACTORS
Average kg/kkg
Finished Product

	COD	BOD	SS	VSS	Total P	TKN	G&O	W.W.[1]
Process Shift	4.6	3.0	1.3	1.3	0.0030	0.016	3.2	1,500
Clean-Up Shift	9.1	6.4	3.0	3.0	0.015	0.022	5.1	1,600
Total Daily Operation	14	9.4	4.4	4.4	0.018	0.038	8.3	3,100

[1] Wastewater Generation in l/kkg finished product.

1 lb/ton = 0.5 kg/kkg
1 gallon/ton = 4.173 l/kkg

- Pre-Treatment Facilities

  There is no pre-treatment at the plant. All wastewater discharges into a small surge tank and then to the sewer.

MEAT SPECIALTIES

- Plant Code: K
- Location: West
- Category: 4
- Products: Fresh frozen and pre-cooked meats:

beef patties, canned turkey, salisbury steak, breaded veal patties, pork patties, canned chicken.

- Significant Ingredients (used during sampling period)

Processed at Plant	Pre-Processed Elsewhere	
None	Beef	Salt
	Turkey	Soy Protein
	Flour	Seasonings

A simplified schematic diagram of plant operations is shown in Figure A-8.

- Sampling Procedure

An automatic sampler was used to take nine time interval samples of the combined raw processing and clean-up wastewater out of a final grease trap.

- Wastewater Characteristics

Combined Process and Clean-Up Wastewaters
(9 a.m. - 11 p.m.)*

	COD	BOD	SS	VSS	Total P	TKN	Grease & Oil
Avg. Conc. (mg/l)	900	530	210	170	15	28	120
Range of Conc. (mg/l)	510- 1,700	290- 860	56- 430	40- 370	1.0- 38	9.5- 56	12- 400

*Nine samples
pH range: 6.2-7.6

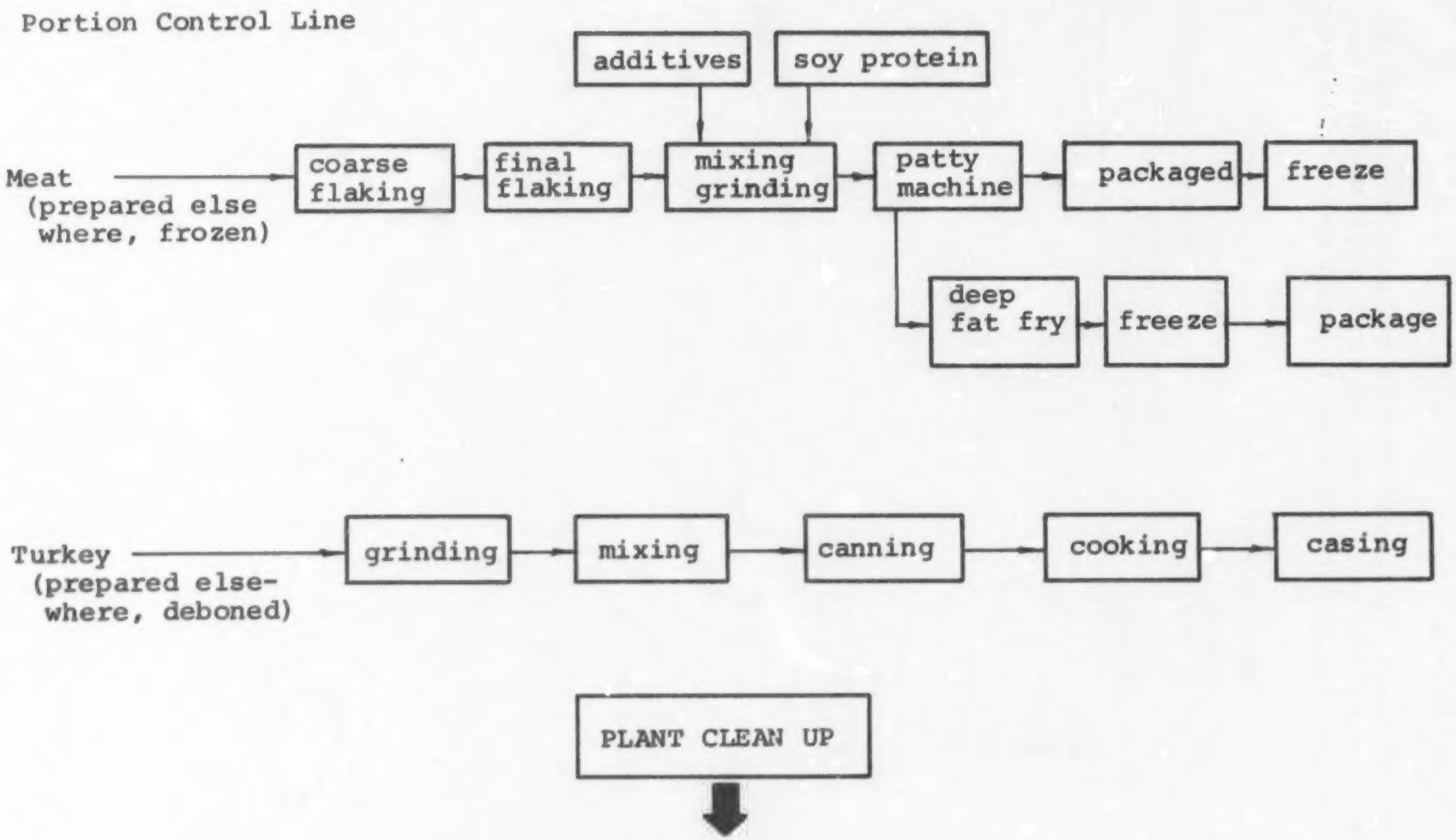

Portion Control Line
additives
soy protein
Meat
(prepared else
where, frozen)
coarse flaking
final flaking
mixing grinding
patty machine
packaged
freeze
deep fat fry
freeze
package
Turkey
(prepared else-
where, deboned)
grinding
mixing
canning
cooking
casing
PLANT CLEAN UP

FIGURE A-8

PLANT K

MEAT PATTY PREPARATION AND CANNING PLANT
SIMPLIFIED PROCESS FLOW DIAGRAM
(heavy arrow designates major
wastewater producing operations)

- Productivity Factors

Based upon average daily wastewater volumes and quality characteristics, and production figures provided by the plant, the following productivity factors were calculated.

PRODUCTIVITY FACTORS
Combined Process and Clean-Up Wastewaters

Constituent	Average kg/kkg finished product
COD	5.1
BOD	3.0
SS	1.2
VSS	0.97
Total P	0.086
TKN	0.16
Grease & Oil	0.68
Wastewater Generation (l/kkg finished product)	5,700

1 gallon/ton = 4.173 l/kkg
1 lb/ton = 0.5 kg/kkg

- Pre-Treatment Facilities

Wastewater pre-treatment equipment at this canned meat plant consists merely of a grease trap.

CANNED MEAT SPECIALTIES

- Plant Code: L
- Location: Midwest
- Category: 4
- Products: Canned meat products:

  potted meat, vienna sausage, beef stew, hash, chile, pork brains, lobster bisque, crab.

- Significant Ingredients (used during sampling period)

Processed at Plant	Pre-Processed Elsewhere	
Sausage (mixing, filling, cooking)	Meat (initial butchering)	
Meat (cutting, deboning, cooking)	Lobster	Vegetables
	Crab	Potatoes
	Beans	Sauces

A simplified schematic diagram of plant operations is shown in Figure A-9.

- Sampling Procedure

  An automatic sampler was installed at the inlet to the wastewater settling tanks and collected nine, time interval composite samples of the total plant effluent and one composite sample of the late shift clean-up operation.

- Wastewater Characteristics

Combined Process and Clean-Up Wastewater*
(6:30 am - 11 pm)

	COD	BOD	SS	VSS	Total P	TKN	Grease & Oil
Avg. Conc. (mg/l)	2,300	1,100	720	670	6.7	67	490
Range of Conc. (mg/l)	1,300-3,300	600-1,400	140-1,200	140-1,100	3.0-20	51-100	100-970

*Nine samples
pH range: 5.5-8.0

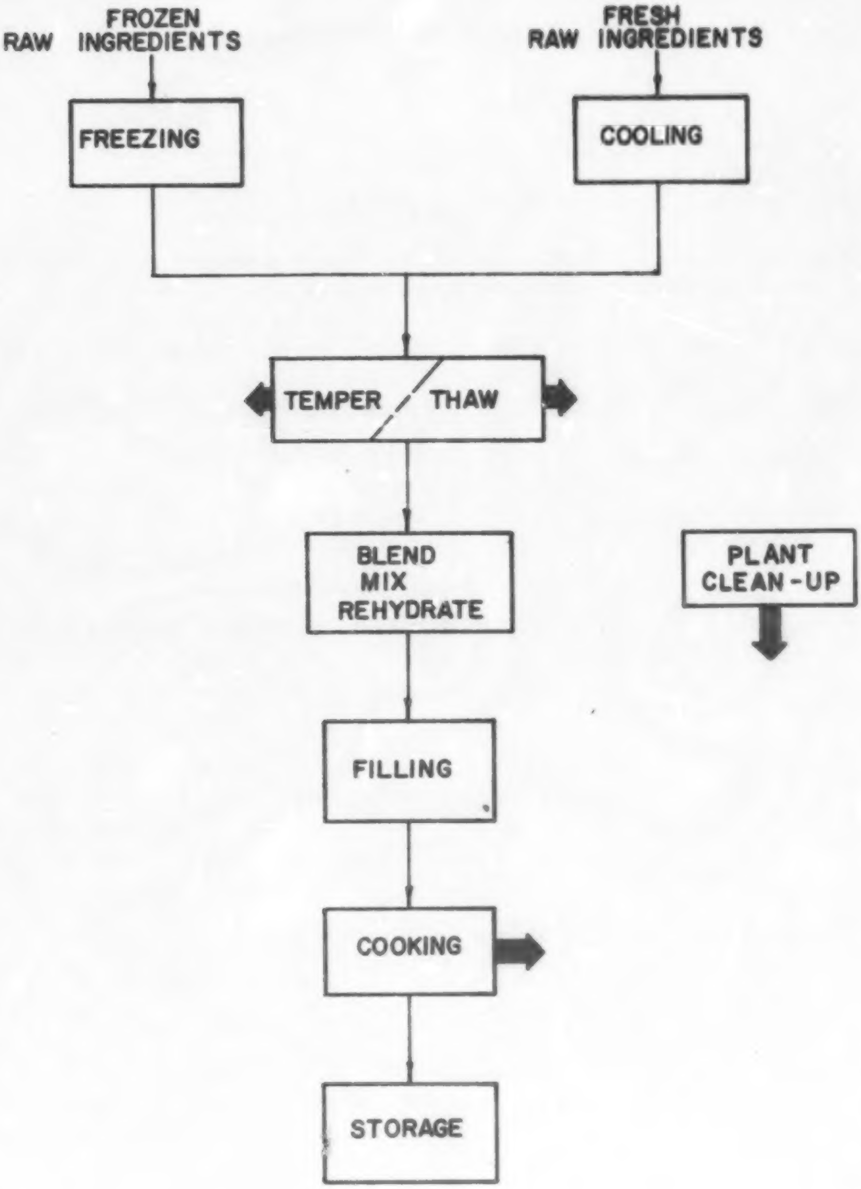

FROZEN RAW INGREDIENTS
FRESH RAW INGREDIENTS
FREEZING
COOLING
TEMPER / THAW
BLEND MIX REHYDRATE
PLANT CLEAN-UP
FILLING
COOKING
STORAGE

FIGURE A-9
PLANT L
CANNED MEAT PLANT
SIMPLIFIED PROCESS FLOW DIAGRAM

(HEAVY ARROWS DESIGNATE MAJOR WASTEWATER GENERATING OPERATIONS)

Clean-Up Wastewater
(11 p.m. - 6:30 a.m.)*

	COD	BOD	pH	SS	VSS	Total P	TKN	Grease & Oil
Concentration (mg/l)	2,300	680	8.4	800	760	11	47	670

*One sample

Based on daily wastewater volumes, wastewater quality characteristics from the lab, and production data supplied by the plant, the following productivity factors were calculated.

PRODUCTIVITY FACTORS
Combined Process and Clean-Up Wastewaters

Constituent	Average kg/kkg finished product	Range kg/kkg finished product
COD	33	22-59
BOD	16	7.7-28
SS	11	5.3-26
VSS	10	5.1-24
Total P	0.11	0.030-0.45
TKN	0.98	0.52-1.8
Grease & Oil	7.3	1.9-22
Wastewater Generation (l/kkg finished product)	15,000	9,100-23,000

1 lb/ton = 0.5 kg/kkg
1 gallon/ton = 4.173 l/kkg

- Pre-Treatment Facilities

Pre-treatment at this canned meat plant consists of aeration and settling for removal of BOD and solids. The effluent is discharged to the city sewer.

BABY FOODS

- Plant Code: M
- Location: West
- Category: 5
- Products: Strained and junior baby foods:

vegetables and meat products, cereal, vegetables, fruit desserts, fruits, fruit juices, starch products, starch and meat products.

- Significant Ingredients (used during sampling period)

Processed at Plant	Pre-Processed Elsewhere		
	Fruit	Meat	Starch
Peaches, (pealed, cored, sliced, mashed, cooked)	Bananas Pineapple Plums	Chicken	Spaghetti
		Dairy	
		Cottage Cheese	

A simplified schematic diagram of plant operations is shown in Figure A-10.

- Sampling Procedure

An automatic sampler was used to collect 10 daily time interval composite samples of the raw waste at the inlet to the pre-treatment units.

- Wastewater Characteristics

Combined Process and Clean-Up Wastewaters*
(8 a.m. - 9 p.m.)

	COD	BOD	pH	SS	VSS	Total P	TKN
Avg. Conc. (mg/l)	1,000	590		280	210	4.1-	12
Range of Conc. (mg/l)	410- 1,700	200- 860	4.3- 9.2	110- 440	100- 260	1.9- 7.6	2.6- 50

*Ten samples

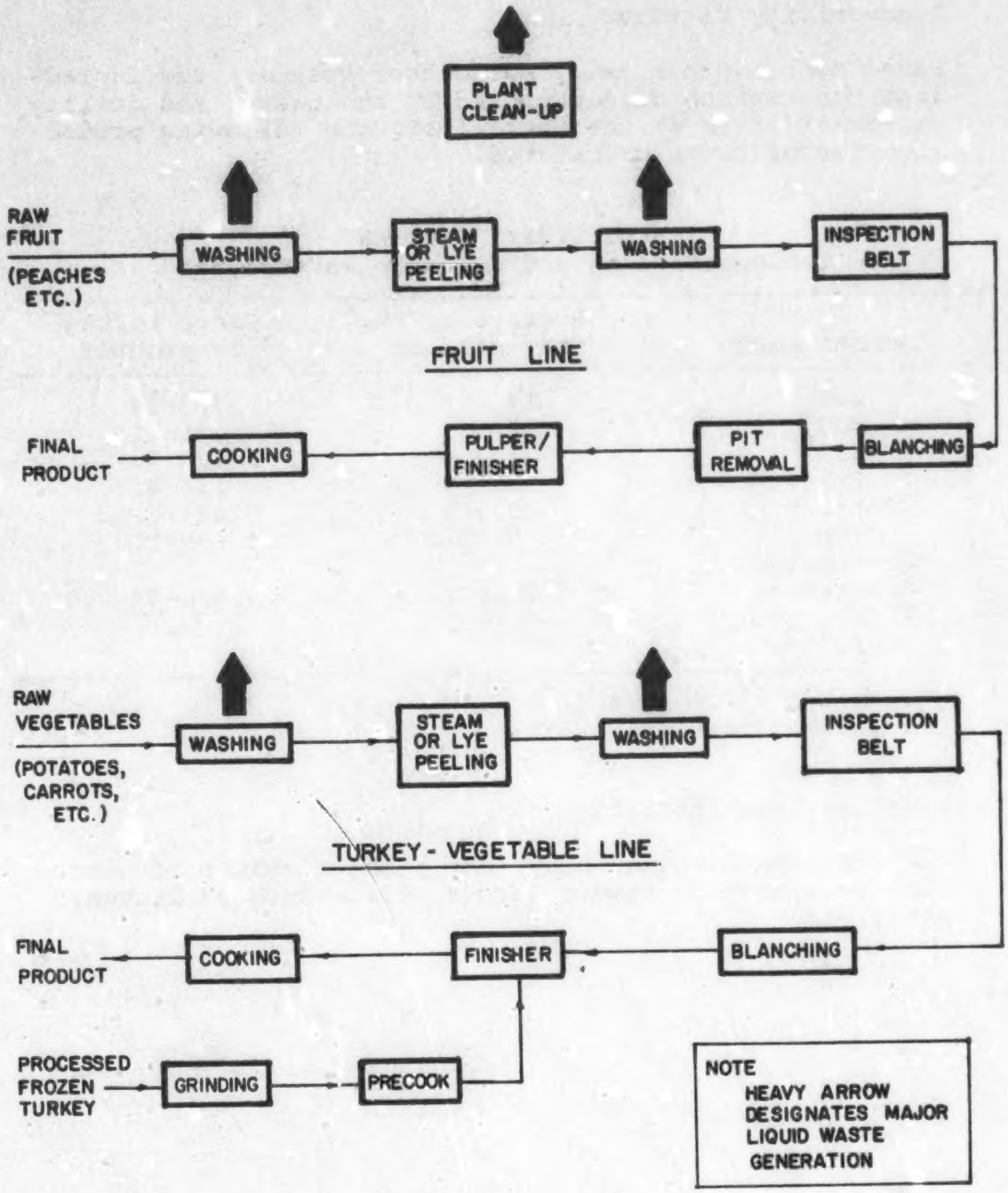

PLANT CLEAN-UP
RAW FRUIT
(PEACHES ETC.)
WASHING
STEAM OR LYE PEELING
WASHING
INSPECTION BELT
FRUIT LINE
FINAL PRODUCT
COOKING
PULPER/ FINISHER
PIT REMOVAL
BLANCHING
RAW VEGETABLES
(POTATOES, CARROTS, ETC.)
WASHING
STEAM OR LYE PEELING
WASHING
INSPECTION BELT
TURKEY - VEGETABLE LINE
FINAL PRODUCT
COOKING
FINISHER
BLANCHING
PROCESSED FROZEN TURKEY
GRINDING
PRECOOK
NOTE
HEAVY ARROW DESIGNATES MAJOR LIQUID WASTE GENERATION

FIGURE A-10
PLANT M

BABY FOOD PLANT
SIMPLIFIED PROCESS FLOW DIAGRAM (2 LINES)

Productivity Factors

Based upon average daily wastewater volumes, raw ingredient consumption data supplied by the plant, and quality characteristics of the wastewater, the following production factors were calculated.

PRODUCTIVITY FACTORS
Combined Process and Clean-Up Wastewaters

Constituent	Average kg/kkg raw product	Range kg/kkg raw product
COD	14	7.3-24
BOD	8.5	3.5-16
SS	4.3	1.8-7.7
VSS	3.1	1.6-4.7
Total P	0.068	0.021-0.13
TKN	0.19	0.039-0.75
Wastewater Generation (l/kkg raw product)	15,000	8,800-24,000

1 lb/ton = 0.5 kg/kkg
1 gallon/ton = 4.173 l/kkg

Pre-Treatment Facilities

Pre-treatment at this baby food plant consists of vibratory screening to remove larger solids such as leaves, pits, etc.

CANNED SOUPS

- Plant Code: N
- Location: Midwest
- Category: 5
- Products: Soups, bean products, juices (tomato, cocktail vegetable), macaroni products, spaghetti products, sauces, gravies, stews (beef, chicken), chili, puddings.

- Significant Ingredients

Processed at Plant	Pre-Processed Elsewhere	
Poultry (cutting, deboning, cooking)	Meat, fish, poultry (initial butchering)	
Meat, fish (cutting, cooking)	Vegetables	Spices
	Dairy products	Salt
	Eggs	Sugar
	Flour	Fats
	Starches	Oils
	Spaghetti	Noodles

- Sampling Procedure

Eight 24-hour composite samples were collected at the inlet to the plant wastewater treatment facility.

In addition, two time interval composite samples were taken during the clean-up shift only (12 midnight - 7:00 a.m.).

- Wastewater Characteristics

Combined Process and Clean-Up Wastewaters
(24 Hour Composites)*

	COD	BOD	SS	VSS	Total P	TKN	Grease & Oil
Avg. Conc. (mg/l)	940	520	360	290	10	26	82
Range of Conc. (mg/l)	760- 1,200	420- 610	210- 840	200- 660	4.3- 21	17- 46	64- 120

*Eight samples
pH range: 6.6-10.5

Clean-Up Wastewater
(12 midnite to 7:00 a.m.)*

	COD	BOD	SS	VSS	Total P	TKN	Grease & Oil
Avg. Conc. (mg/l)	770	410	380	290	17	41	220
Range of Conc. (mg/l)	510- 1,000	260- 570	290- 470	200- 370	16- 18	38- 44	76- 360

*Two samples
pH range: 11.8-11.8

- Productivity Factors

  Based on metered daily wastewater flows, wastewater quality characteristics, and average daily raw ingredient consumption data supplied by the plant, the following productivity factors were calculated.

PRODUCTIVITY FACTORS
Combined Process and Clean-Up Wastewaters

Constituent	Average kg/kkg raw product
COD	27
BOD	15
SS	10
VSS	8.4
Total P	0.29
TKN	0.75
Grease & Oil	2.4
Wastewater Generation (l/kkg raw product)	29,000

1 lb/ton = 0.5 kg/kkg
1 gal/ton = 4.173 l/kkg

- **Treatment Facilities**

  The wastewater treatment facilities consist of the following operations:

  - bar screening
  - gravity grit removal
  - air flotation (with chemical coagulation)
  - primary trickling filter treatment
  - clarification
  - secondary trickling filter treatment
  - aerated lagooning
  - final clarification
  - chlorination
  - anaerobic sludge digestion

  The treated effluent is discharged to a river.

TOMATO-CHEESE-STARCH COMBINATIONS

- Plant Code: O
- Location: Midwest
- Category: 6
- Products: Tomato-cheese-starch combinations (Institutional):

  chili with beans, veal parmagiana, beef ravioli, grilled american cheese, macaroni and cheese, salads.

- Significant Ingredients (used during sampling period)

Processed at Plant	Pre-Processed Elsewhere	
Various salad components (blanching)	Juices	Dressings
	Spices	Lettuce
	Meat	Bread
	Kidney beans	Margarine
	Tomatoes	Macaroni
	Cheese	Milk
	Flour	

A simplified schematic diagram of plant operations is shown in Figure A-11.

- Sampling Procedure

  Ten 24-hour composite samples of the screened raw waste were collected by the plant staff prior to the wastewater treatment facilities.

- Wastewater Characteristics

Combined Process and Clean-Up Wastewaters
(24 Hour Composites)*

	COD	BOD	pH	SS	VSS	Total P	TKN
Avg. Conc. (mg/l)	500	240		180	150	10	7.6
Range of Conc. (mg/l)	79-1,500	20-760	8.7-11.0	62-400	42-390	4.9-16	3.0-14

*Ten samples

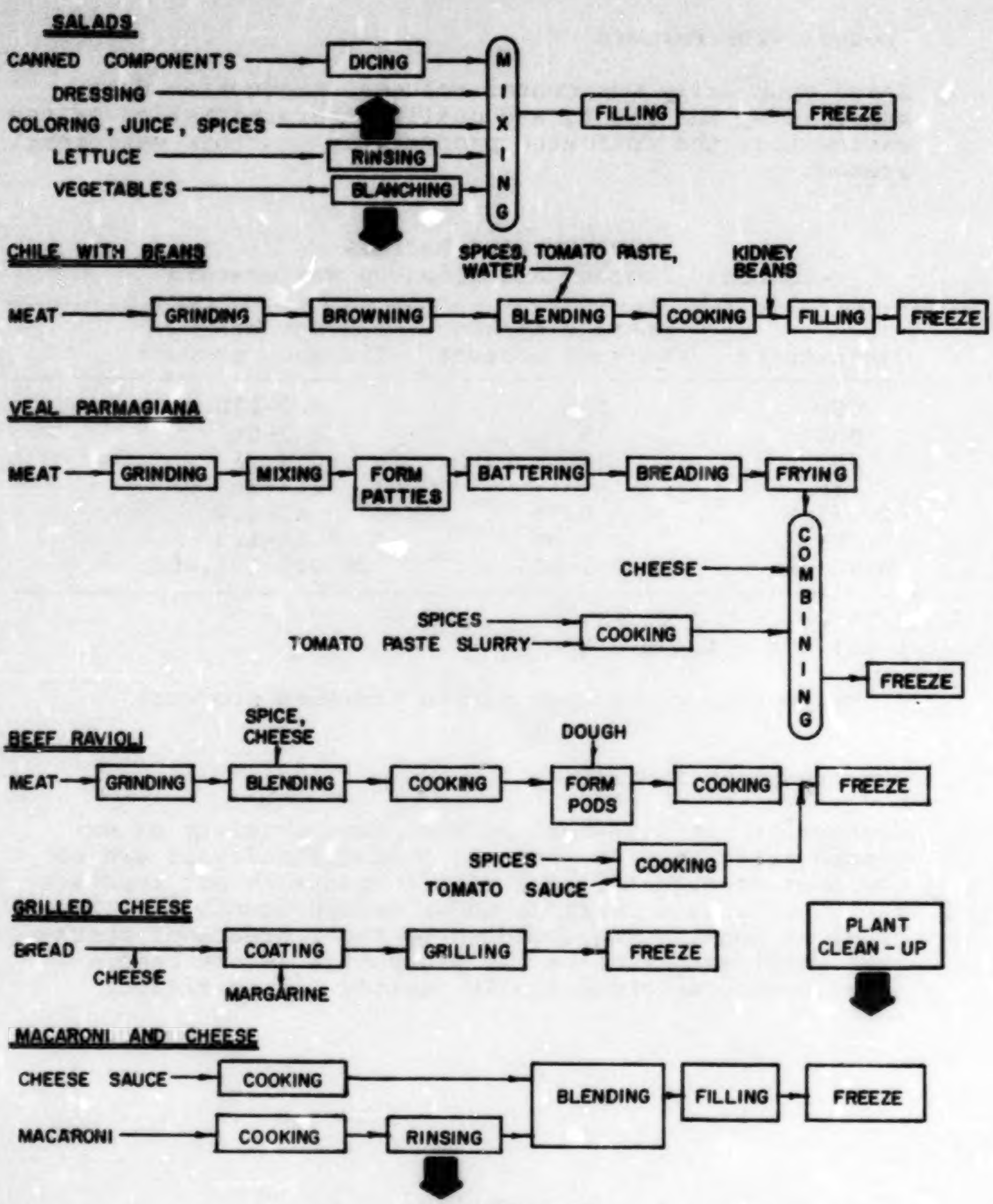

SALADS
CANNED COMPONENTS
DRESSING
COLORING, JUICE, SPICES
LETTUCE
VEGETABLES
DICING
RINSING
BLANCHING
MIXING
FILLING
FREEZE
CHILE WITH BEANS
MEAT
GRINDING
BROWNING
SPICES, TOMATO PASTE, WATER
BLENDING
COOKING
KIDNEY BEANS
FILLING
FREEZE
VEAL PARMAGIANA
MEAT
GRINDING
MIXING
FORM PATTIES
BATTERING
BREADING
FRYING
CHEESE
COMBINING
SPICES
TOMATO PASTE SLURRY
COOKING
FREEZE
BEEF RAVIOLI
MEAT
GRINDING
SPICE, CHEESE
BLENDING
COOKING
DOUGH
FORM PODS
COOKING
FREEZE
SPICES
TOMATO SAUCE
COOKING
GRILLED CHEESE
BREAD
CHEESE
COATING
MARGARINE
GRILLING
FREEZE
PLANT CLEAN - UP
MACARONI AND CHEESE
CHEESE SAUCE
COOKING
MACARONI
COOKING
RINSING
BLENDING
FILLING
FREEZE

FIGURE A-11
PLANT O
TOMATO-CHEESE-STARCH PRODUCTS PLANT
SIMPLIFIED PROCESS FLOW DIAGRAM
(HEAVY ARROW DESIGNATES MAJOR WASTEWATER GENERATING OPERATIONS)

- **Productivity Factors**

Based upon daily wastewater volumes, production data supplied by the plant, and quality characteristics of the wastewater, the following productivity factors were generated.

PRODUCTIVITY FACTORS
Combined Process and Clean-Up Wastewaters

Constituent	Average kg/kkg finished product	Range kg/kkg finished product
COD	39	4.7-110
BOD	19	2.2-54
SS	14	2.4-31
VSS	13	1.6-28
Total P	0.79	0.42-1.7
TKN	0.59	0.14-1.3
W.W.(1)	80,000	39,000-134,000

1 lb/ton = 0.5 kg/kkg
1 gal/ton = 4.173 l/kkg

(1) Wastewater generation (l/kkg finished product)

- **Pre-treatment Facilities**

Wastewater pre-treatment at the plant consists of extended aeration. At present, production levels are so low that treatment facility performance is not representative of what it will be under design loadings. The plant is considering shutdown of their treatment operation until such time as the production levels become large enough to economically justify its operation.

TOMATO-CHEESE-STARCH COMBINATIONS

- Plant Code: P (Historical Data Only)
- Location: West
- Category: 6
- Products: Tomato-cheese-starch combinations (canned):

  chili con carne, meat balls with gravy, spaghetti (with meat balls, with cheese), ravioli (beef, cheese), stew (beef, meat ball), tomato pastes, tomato sauce (with meat, with mushrooms), lasagne, manicotti, beefaroni.

- Significant Ingredients (used during sampling period)

Processed at Plant	Pre-Processed Elsewhere	
None	Tomatoes (processed at plant during tomato season)	
	Beef	Vegetables
	Cheese	Seasonings
	Flour	Mushrooms
	Cereals	

- Sampling Procedure

  An automatic sampler was used to collect six 24-hour flow proportional samples of the raw plant wastewater. All the effluent was discharged from the kitchen operation as no tomatoes were being processed.

  The samples were collected during the period of 7/6/72-7/17/72.

- Wastewater Characteristics

Combined Process and Clean-Up Wastewater
(24 Hour Composites)*

	BOD	pH	TS[1]	TKN
Average Conc. (mg/l)	340		920	12
Range of Conc. (mg/l)	210- 420	6.9- 7.8	750- 1,100	6.5- 20

*Six samples
[1] Total Solids

- **Productivity Factors**

Based on daily wastewater flow measurements, wastewater quality characteristics from the lab, and average daily production data supplied by the plant, the following productivity factors were calculated.

PRODUCTIVITY FACTORS
Kitchen Operation
(No Tomato Processing)

Combined Process and
Clean-Up Wastewaters

Constituent	Average kg/kkg finished product
BOD	3.3
Total Solids	9.0
TKN	0.12
Wastewater Generation (l/kkg finished product)	9,800

1 lb/ton = 0.5 kg/kkg
1 gallon/ton = 4.173 l/kkg

- **Pre-Treatment Facilities**

Wastewater treatment at the plant consists of screening and aeration, followed by retention in stabilization ponds. The final effluent is chlorinated and discharged to a creek.

TOMATO-CHEESE-STARCH COMBINATIONS

- Plant Code: Q
- Location: East
- Category: 6
- Products: Tomato-cheese-starch combinations:

  lasagne, ravioli, spaghetti, pizza.

- Significant Ingredients (used during sampling period)

Processed at Plant	Pre-Processed Elsewhere	
None	Beef	Seasonings
	Pork	Cheese
	Flour	Tomato
	Milk	Green pepper
	Oil	Onion

- Sampling Procedure

  An automatic sampler was used to collect eight 24-hour, time interval composite samples of the raw plant wastewater. The samples were taken just upstream from the plant's wastewater screening operation.

- Wastewater Characteristics

Combined Process and Clean-Up Wastewater
(24 Hour Composites)*

	COD	BOD	SS	VSS	Total P	TKN	Grease & Oil
Avg. Conc. (mg/l)	340	200	130	120	2.0	5.6	180
Range of Conc. (mg/l)	150- 560	79- 300	50- 240	50- 240	0.50- 4.2	0.20- 11	13- 380

*Five samples
pH range: 6.1-7.6

- **Productivity Factors**

Based upon average daily wastewater volumes, production data supplied by the plant, and wastewater quality characteristics from the lab, the following productivity factors were calculated.

PRODUCTIVITY FACTORS
Combined Process and Clean-Up Wastewaters

Constituent	Average kg/kkg finished product
COD	8.8
BOD	5.2
SS	3.4
VSS	3.1
Total P	0.052
TKN	0.15
Grease & Oil	4.7
Wastewater Generation (l/kkg finished product)	26,000

1 lb/ton = 0.5 kg/kkg
1 gallon/ton = 4.173 l/kkg

- **Pre-Treatment Facilities**

Pre-treatment at this plant consists merely of screening for solids removal prior to discharge to the city sewer.

TOMATO-CHEESE-STARCH COMBINATIONS

- Plant Code: R
- Location: East
- Category: 6
- Products: Tomato-cheese-starch Combinations:

  lasagne, pizza, eggplant parmigiana.

- Significant Ingredients (used during sampling period)

Processed at Plant	Pre-Processed Elsewhere	
Eggplant (washed, peeled, sliced)	Beef	Cheese
	Flour	Tomato
	Milk	Onion
	Oil	Green pepper
	Seasonings	

- A simplified schematic diagram of plant operations is shown in Figure A-12.

- Sampling Procedure

  An automatic sampler was used to collect ten time interval, composite samples of the raw plant wastewater just prior to discharge into the municipal sewer system.

- Wastewater Characteristics

Combined Process and Clean-Up Wastewaters
(8 a.m. - 5 p.m.)*

	COD	BOD	SS	VSS	Total P	TKN
Avg. Conc. (mg/l)	1,450	690	360	330	6.0	34
Range of Conc. (mg/l)	400- 5,400	180- 3,000	85- 1,500	65- 1,300	1.6- 18	15- 110

*Ten samples
pH range: 5.5-7.7

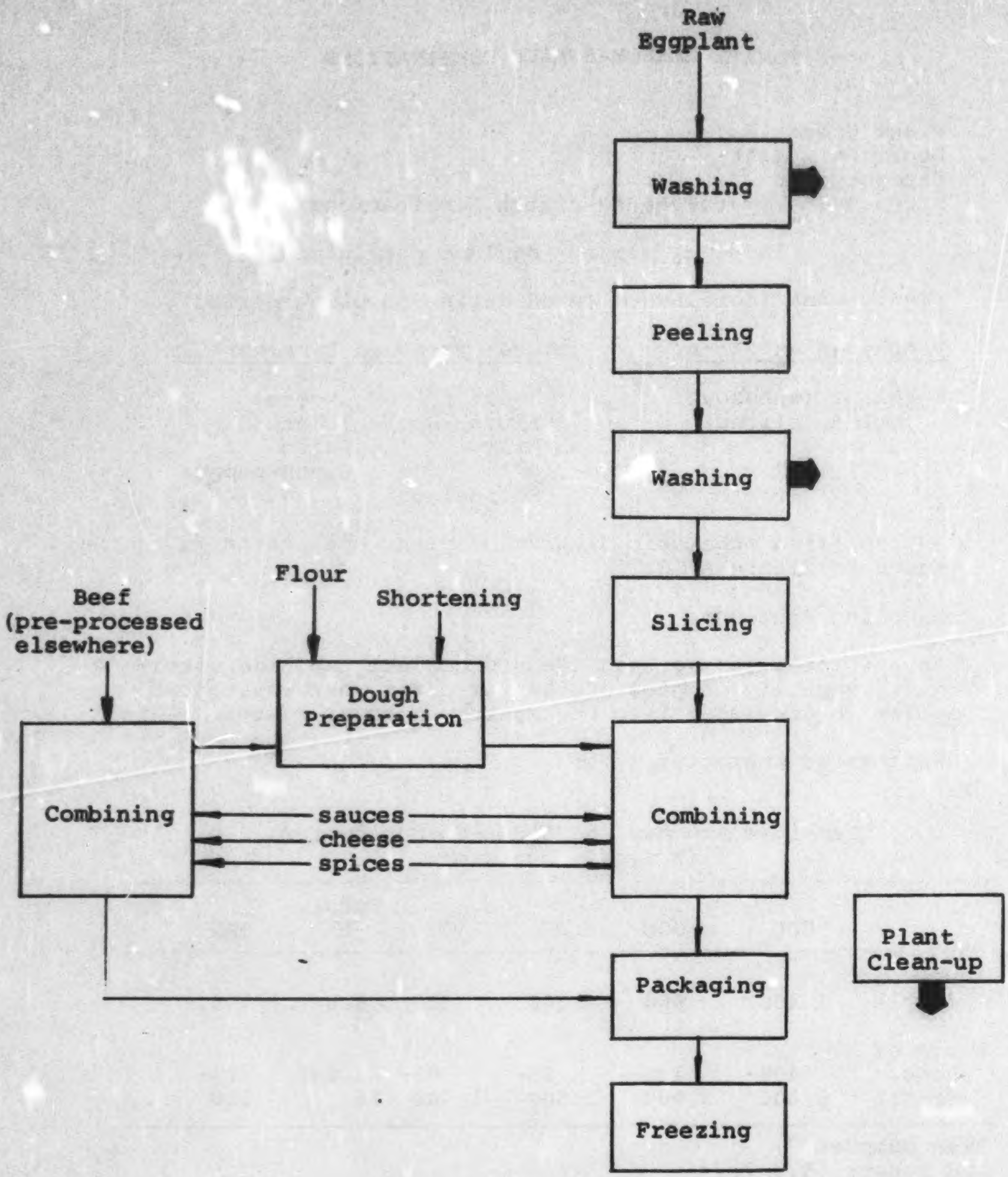

Raw
Eggplant
Washing
Peeling
Washing
Slicing
Flour
Shortening
Beef
(pre-processed
elsewhere)
Dough
Preparation
Combining
sauces
cheese
spices
Combining
Packaging
Freezing
Plant
Clean-up

FIGURE A-12

PLANT R
TOMATO-CHEESE-STARCH PRODUCTS PLANT
SIMPLIFIED PROCESS FLOW DIAGRAM
(heavy arrows designate major wastewater generating operations)

- **Productivity Factors**

Based upon average daily wastewater volumes, raw material consumption data supplied by the plant, and wastewater quality characteristics from the lab, the following productivity factors were calculated.

PRODUCTIVITY FACTORS
Combined Process and Clean-Up Wastewaters

Constituent	Average kg/kkg raw product
COD	2.6
BOD	1.2
SS	0.65
VSS	0.59
Total P	0.011
TKN	0.061
Wastewater Generation (l/kkg raw product)	1,800

1 lb/ton = 0.5 kg/kkg
1 gallon/ton = 4.173 l/kkg

- **Pre-Treatment Facilities**

At present, there is no wastewater pre-treatment at this food plant.

SAUCED VEGETABLES

- Plant Code: S
- Location: West
- Category: 7
- Products: Vegetables

Processed: cauliflower (bulk; with cheese sauce), brussel sprouts (bulk; with butter sauce), spinach (bulk; with butter sauce), broccoli (bulk; with butter sauce; with cheese sauce).
Repackaged: corn, peas, green beans, lima beans.

- Significant Ingredients (used during sampling period)

Processed at Plant	Pre-Processed Elsewhere	
Broccoli	Butter	Cheese
Cauliflower	Shortening	Salt
	Sugar	

A simplified schematic diagram of plant operations is shown in Figure A-13.

- Sampling Procedure

An automatic sampler was used to obtain ten time interval, 24 hour composite samples of the raw waste prior to vibratory screening at the food plant.

In addition, three grab samples of the sauce room clean-up wastewater were manually collected.

- Wastewater Characteristics

Combined Process and Clean-Up Wastewaters
(24 Hour Composites)*

	COD	BOD	pH	SS	VSS	Total P	TKN
Avg. Conc. (mg/l)	560	310		250	200	4.4	13
Range of Conc. (mg/l)	380-890	140-550	7.0-7.7	170-410	130-360	1.9-9.9	5.1-27

*Ten samples

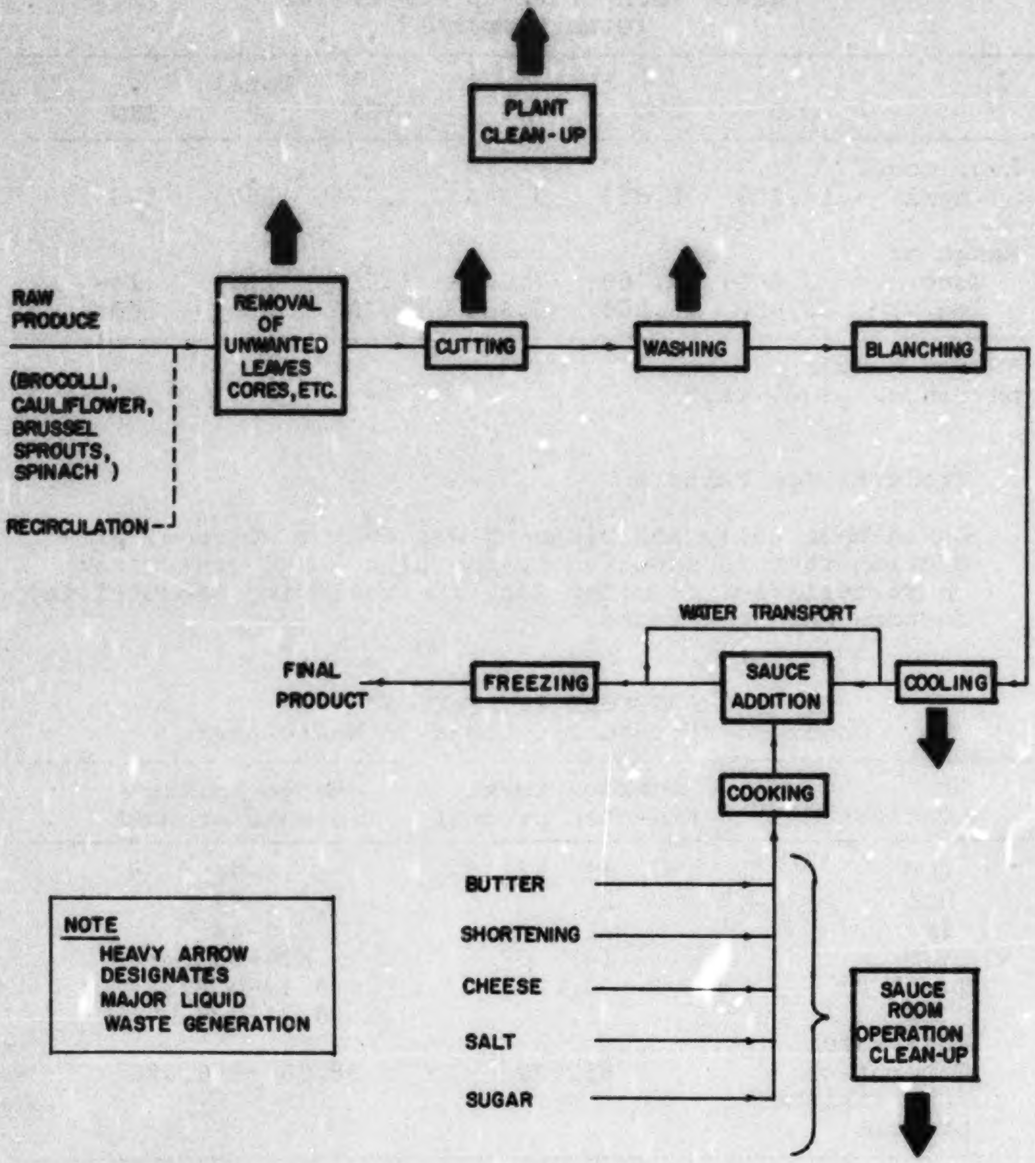

PLANT CLEAN-UP
RAW PRODUCE
(BROCOLLI, CAULIFLOWER, BRUSSEL SPROUTS, SPINACH)
RECIRCULATION
REMOVAL OF UNWANTED LEAVES CORES, ETC.
CUTTING
WASHING
BLANCHING
WATER TRANSPORT
FINAL PRODUCT
FREEZING
SAUCE ADDITION
COOLING
COOKING
BUTTER
SHORTENING
CHEESE
SALT
SUGAR
SAUCE ROOM OPERATION CLEAN-UP
NOTE
HEAVY ARROW DESIGNATES MAJOR LIQUID WASTE GENERATION

FIGURE A-13
PLANT S
SAUCED VEGETABLE PLANT
SIMPLIFIED PROCESS FLOW DIAGRAM

Sauce Room Clean-Up Wastewater
(Grab Samples)*

	COD	BOD	SS	VSS	Total P	TKN
Avg. Conc. (mg/l)	14,000	8,052	3,340	3,078	227	104
Range of Conc. (mg/l)	3,400-28,000	2,200-16,000	1,000-5,600	1,000-5,100	130-280	14-160

*Three samples
pH range: 10.9-11.9

- Productivity Factors

Based upon daily and clean-up wastewater volumes, production factors supplied by the plant, and wastewater characteristics from the lab, the following productivity factors were generated.

PRODUCTIVITY FACTORS
Combined Process and Clean-Up Wastewaters

Constituent	Average kg/kkg finished product	Range kg/kkg finished product
COD	45	16-76
BOD	25	7.1-47
SS	21	7.0-44
VSS	16	6.0-30
Total P	0.33	0.12-0.53
TKN	1.1	0.31-2.9
Wastewater Generation (l/kkg finished product)	85,000	38,000-160,000

1 gallon/ton = 4.173 l/kkg
1 lb/ton = 0.5 k/kkg

The table on the following page shows the portion of total kg/kkg production contributed by clean-up of the sauce room where all the dairy operations are performed (e.g., cheese sauce and butter sauce preparation).

Sauce Room Clean-Up Wastewater

Constituent	Average kg/kkg finished product	% of total pollutant load
COD	6.4	15
BOD	3.5	14
SS	1.4	7
VSS	1.3	8
Total P	0.090	27
TKN	0.047	4
Wastewater generation (l/kkg finished product)	490	0.6

- Pre-Treatment Facilities

Pre-treatment at the sauced vegetable plant consists of 20 mesh vibratory screening for removal of solids.

SWEET SYRUP PRODUCTS

- Plant Code: T
- Location: East
- Category: 8
- Products: Sweet syrup products:

chocolate and cocoa products, ready mixed desserts, syrups, whipped toppings, coconut based products, tapioca.

- Significant Ingrients (used during sampling period)

Processed at Plant	Pre-Processed Elsewhere	
Rice	Fats and oils	
Chocolate	Flavorings	
Cocoa	Milk powder	
Syrups	Syrups	Starches
	Coconut	Sugar

A simplified plant wastewater flow diagram is shown in Figure A-14.

- Sampling Procedure

An automatic sampler was used to collect six 24-hour composite samples of the total raw effluent and two 24-hour composite samples of the raw rice processing wastewater. In addition, two grab sample composites of the rice wastewater treatment plant effluent were taken. Sampling locations are noted in Figure A-14.

- Wastewater Characteristics

Total Plant Wastewater
(24 Hour Composites*)

	COD	BOD	pH	SS	VSS	Total P	TKN	Grease and Oil
Avg. Conc. (mg/l)	2,000	1,100		470	410	28	21	230
Range of Conc. (mg/l)	1,800- 2,300	920- 1,600	5.9- 7.4	350- 620	340- 480	20- 38	14- 35	170- 280

*Six samples

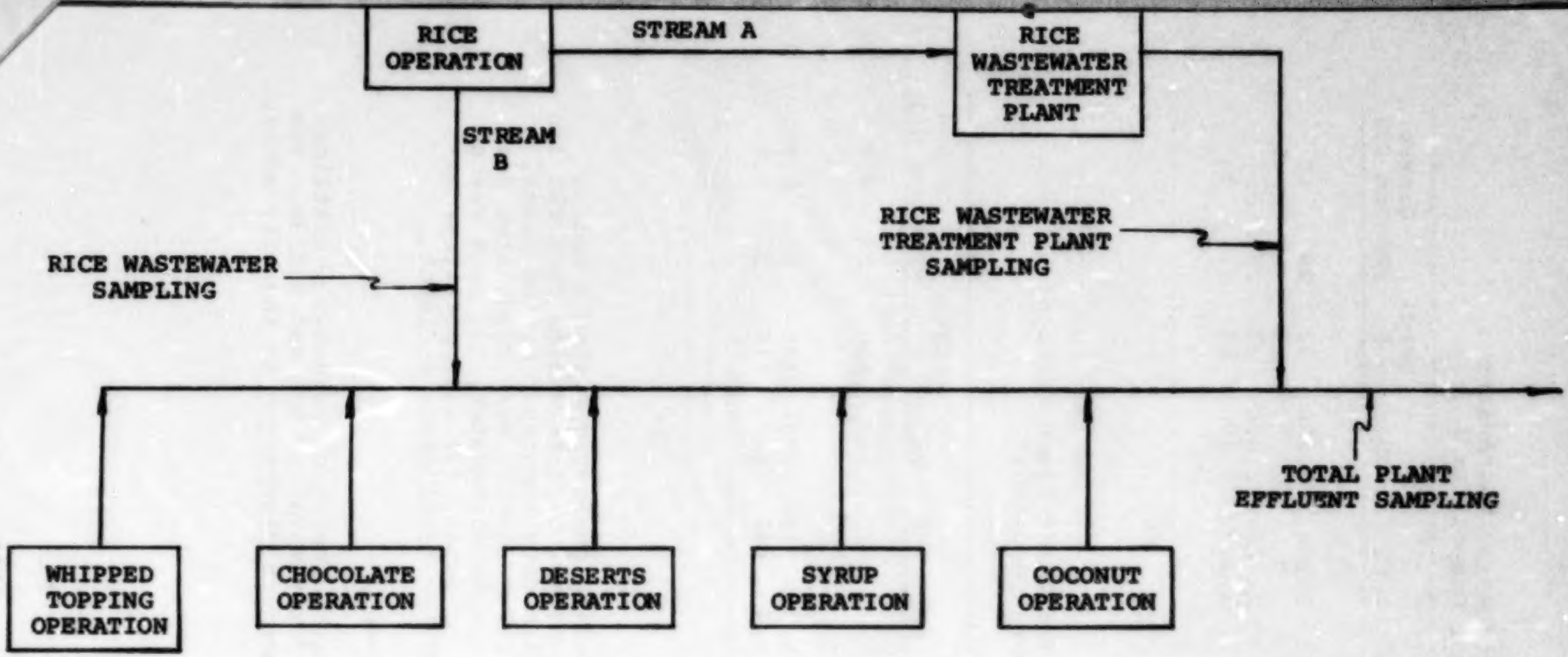

RICE OPERATION
STREAM A
RICE WASTEWATER TREATMENT PLANT
STREAM B
RICE WASTEWATER SAMPLING
RICE WASTEWATER TREATMENT PLANT SAMPLING
TOTAL PLANT EFFLUENT SAMPLING
WHIPPED TOPPING OPERATION
CHOCOLATE OPERATION
DESERTS OPERATION
SYRUP OPERATION
COCONUT OPERATION

FIGURE A-14

PLANT T

CHOCOLATE AND CANDY PLANT
SIMPLIFIED WASTEWATER FLOW DIAGRAM

Raw Rice Processing Wastewater
(24 Hour Composites*)

	COD	BOD	SS	VSS	Total P	TKN	Grease and Oil
Avg. Conc. (mg/l)	4,000	3,000	3,100	3,000	32	29	10
Range of Conc. (mg/l)	3,600-4,400	2,400-3,600	2,900-3,300	2,900-3,200	27-38	26-31	0.7-20

*Two samples
pH range: 6.6-6.8

Rice Wastewater Treatment Plant Effluent
(24 Hour Composites*)

	COD	BOD	pH	SS	VSS	Total P	TKN	Grease and Oil
Avg. Conc. (mg/l)	340	34.5		320	240	110	24	4.4
Range of Conc. (mg/l)	260-420	16-53	5.7-6.4	210-440	180-300	100-110	12-35	0.9-7.9

*Two samples

- Productivity Factors

  Based on wastewater volume generated during sampling periods, wastewater quality characteristics from the lab analysis, and production data furnished by the plant, the following productivity factors were calculated for (1) the raw rice processing wastewater, (2) rice wastewater treatment plant effluent, (3) all operations except the rice, and (4) the total plant effluent.

- Pre-Treatment Facilities

  Pre-treatment facilities consist of screening, settling, and activated sludge for removal of BOD and solids. The treatment plant effluent is discharged to the city sewer.

Productivity Factors
Average k/kkg Finished Product

	COD	BOD	SS	VSS	Total P	TKN	Grease and Oil	Waste-water[1]
Raw rice processing wastewater	0.48	0.36	0.37	0.36	0.0038	0.0035	0.0012	120
Rice wastewater treatment plant effluent	0.20	0.021	0.19	0.14	0.067	0.014	0.0026	600
All process and clean-up except rice operation	4.7	2.6	0.74	0.60	0.0052	0.040	0.62	2,000
Total plant effluent	5.4	3.0	1.3	1.1	0.076	0.057	0.62	2,700

[1] Wastewater generation in 1/kkg finished product

JAMS AND JELLIES

- Plant Code: U
- Location: West
- Category: 8
- Products: Jams, jellies, preserves, apple butter, peach butter, toppings, syrups

- Significant Ingredients (used during processing period)

Processed at Plant	Pre-Processed Elsewhere	
None	Strawberries	Corn syrup
	Oranges	Carmel
	Pineapples	Butterscotch
	Cherries	Chocolate
	Peaches	Pectin
	Plums	Sugar
	Grapes	Acid
	Blackberries	Apricots
	Red raspberries	Blueberries

A simplified schematic diagram of plant operations is shown in Figure A-15.

- Sampling Procedures

An automatic sampler was used to take eight 24-hour time interval composite samples of the raw plant wastewater at the final manhole before discharge to the city sewer.

- Wastewater Characteristics

Combined Process and Clean-up Wastewaters
(24 Hour Composites*)

	COD	BOD	pH	SS	VSS	Total P	TKN
Avg. Conc. (mg/l)	6,100	3,600		340	300	9.6	15
Range of Conc. (mg/l)	3,600-8,400	2,200-4,700	4.8-7.0	170-780	150-700	2.6-26	6.4-36

*Eight samples

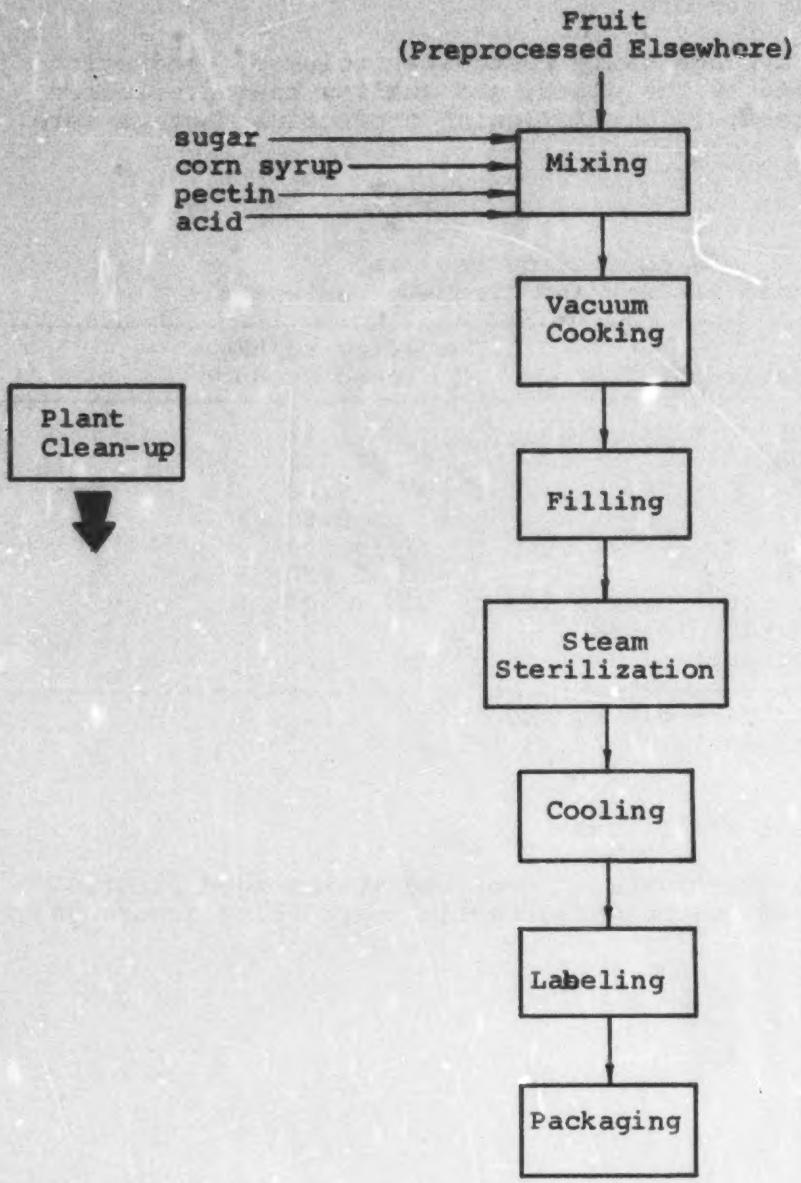

Fruit
(Preprocessed Elsewhere)
sugar
corn syrup
pectin
acid
Mixing
Vacuum Cooking
Plant Clean-up
Filling
Steam Sterilization
Cooling
Labeling
Packaging

FIGURE A-15

PLANT U

JAMS AND JELLIES PLANT
SIMPLIFIED PROCESS DIAGRAM
(heavy arrow designates major
wastewater producing operations)

- **Productivity Factors**

Based upon average daily wastewater volumes, production data supplied by the plant, and quality characteristics of the wastewater, the following production factors were calculated.

Productivity Factors
Combined Process and Clean-Up Wastewaters

Constituent	Average kg/kkg Finished Product
COD	12
BOD	7.2
SS	0.68
VSS	0.60
Total P	0.019
TKN	0.030
Wastewater Generation (l/kkg finished product)	2,000

1 lb/ton = 0.5 kg/kkg
1 gallon/ton = 4.173 l/kkg

- **Pre-Treatment Facilities**

There is no pre-treatment provided at the food plant. Wastewater is discharged directly to the city sewer system.

CHINESE FOODS

- Plant Code: V
- Location: Midwest
- Category: 9
- Products: Chinese foods

  Mixed vegetables, chop suey vegetables, chow mein, fried rice, bean sprouts, noodles, water chestnuts, bamboo shoots, won ton soup, egg drop soup, teriyaki sauce, singapore salad, brown gravy sauce.

- Significant Ingredients (used during sampling period)

Processed at Plant

Bean sprouts (sprouting, washing, blanching)
Rice (cooking or frying)
Noodles
Chicken, beef, pork, shrimp (cutting cooking, frying)
Celery (washing, blanching)

Pre-Processed Elsewhere

Vegetables (except bean sprouts, celery)
Chicken, beef (initial cleaning)
Shrimp (peeling, cleaning)
Spices
Seasonings
Eggs
Flour

A simplified schematic diagram of plant operations is shown in Figure A-16.

- Sampling Procedure

An automatic sampler was used to take nine 24-hour time interval composite samples of the screened plant wastewater at the outlet from the holding tank.

- Wastewater Characteristics

Combined Process and Clean-Up Wastewater
(24 Hour Composites*)

	COD	BOD	pH	SS	VSS	Total P	TKN	Grease & Oil
Avg. Conc. (mg/l)	830	450		170	160	6.0	26	85
Range of Conc. (mg/l)	760-920	380-590	5.0-5.9	140-210	120-200	4.2-7.4	22-29	17-230

*Nine samples

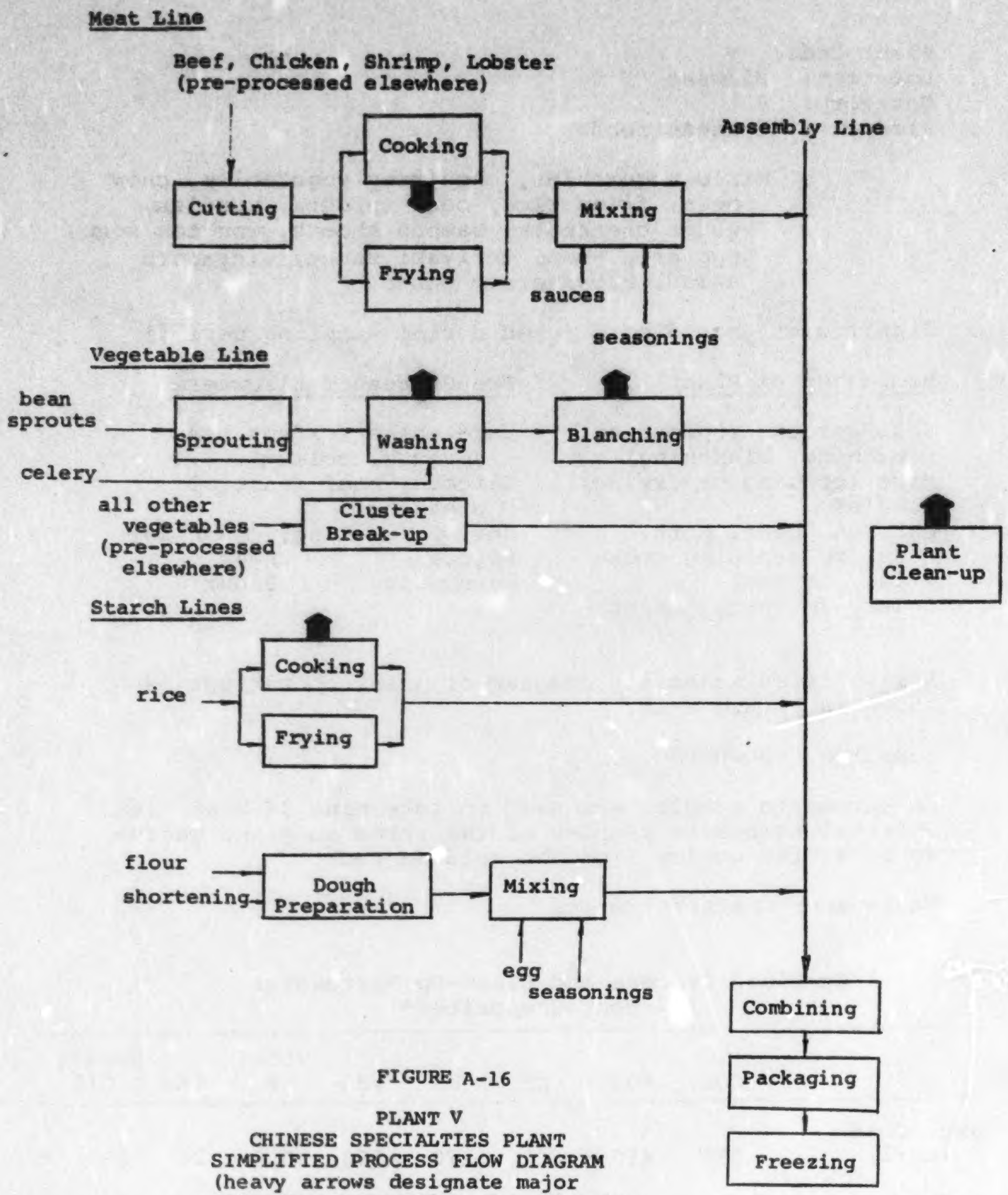

Meat Line
Beef, Chicken, Shrimp, Lobster
(pre-processed elsewhere)
Cutting
Cooking
Frying
Mixing
sauces
seasonings
Assembly Line
Vegetable Line
bean
sprouts
Sprouting
Washing
Blanching
celery
all other
vegetables
(pre-processed
elsewhere)
Cluster
Break-up
Plant
Clean-up
Starch Lines
rice
Cooking
Frying
flour
shortening
Dough
Preparation
Mixing
egg
seasonings
Combining
Packaging
Freezing

FIGURE A-16

PLANT V
CHINESE SPECIALTIES PLANT
SIMPLIFIED PROCESS FLOW DIAGRAM
(heavy arrows designate major
wastewater generating operations)

- **Productivity Factors**

  Based upon average daily wastewater volume, wastewater quality characteristics, and production data supplied by the plant, the following productivity factors were calculated.

Productivity Factors
Combined Process and Clean-Up Wastewaters

Constituent	Average kg/kkg Finished Product
COD	12
BOD	6.3
SS	2.4
VSS	2.2
Total P	0.084
TKN	0.36
Grease and Oil	1.2
Wastewater Generation (l/kkg finished product)	14,000

1 lb/ton = 0.5 kg/kkg
1 gallon/ton = 4.173 l/kkg

- Pre-Treatment Facilities

  Pre-treatment consists merely of screening for solids removal.

CHINESE FOODS

- Plant Code: W
- Location: Midwest
- Category: 9
- Products: Chinese Foods

Prepared Dinners: beef chow mein, chicken chow mein, shrimp chow mein, egg foo young.
Entrees: Shrimp eggrolls, chicken eggrolls, lobster eggrolls, meat eggrolls, fried rice with meat, chichen chow mein, shrimp chow mein, beef chow mein, pork chow mein, sweet and sour pork.
Miscellaneous: Soy sauce, chow mein vegetables, bean sprouts, noodles.

- Significant Ingredients (used during sampling period)

Processed at Plant	Pre-Processed Elsewhere
Bean sprouts (sprouting, washing)	Beef, pork, chicken (initial cleaning)
Rice (cooked)	Shrimp, lobster (peeling, cleaning, cutting)
Noodles	
Chicken, beef, pork, shrimp (cutting, cooking or frying)	Eggs Flour Seasonings
Celery (washing, blanching)	

A simplified schematic diagram of plant operations is shown in Figure A-17.

- Sampling Procedure

An automatic sampler was used to collect nine time interval composite samples of the raw plant wastewater from a sump just ahead of the pre-treatment facility.

- Wastewater Characteristics

Combined Process and Clean-Up Wastewaters
(8 a.m. - 9 p.m.*)

	COD	BOD	pH	SS	VSS	Total P	TKN	Grease and Oil
Avg. Conc. (mg/l)	670	370		220	210	2.3	15	260
Range of Conc. (mg/l)	420-1,200	230-600	4.6-10.2	110-490	94-450	0.04-5.1	7.1-22	53-920

*Nine samples

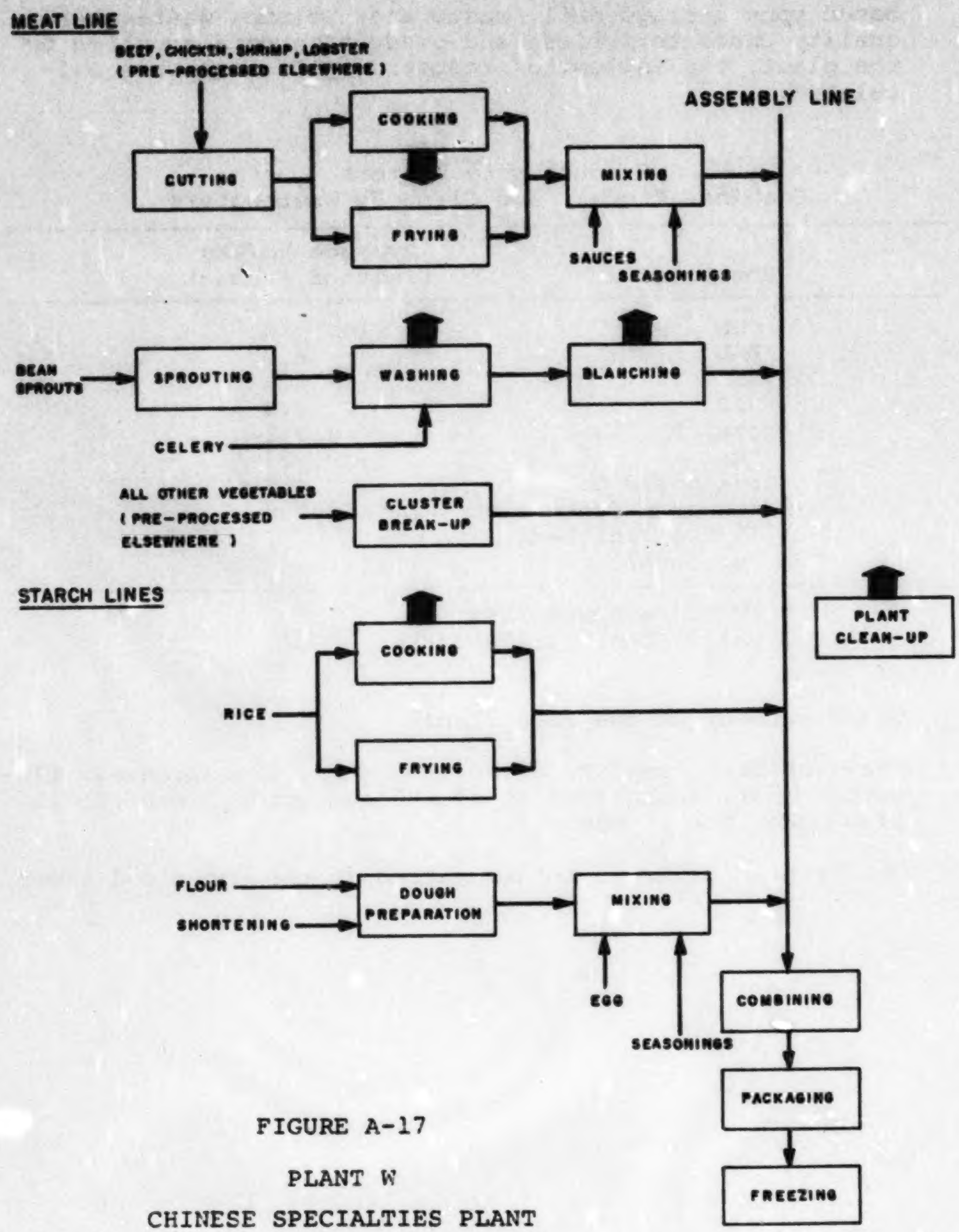

MEAT LINE
BEEF, CHICKEN, SHRIMP, LOBSTER
(PRE-PROCESSED ELSEWHERE)
CUTTING
COOKING
FRYING
MIXING
SAUCES
SEASONINGS
ASSEMBLY LINE
BEAN SPROUTS
SPROUTING
WASHING
BLANCHING
CELERY
ALL OTHER VEGETABLES (PRE-PROCESSED ELSEWHERE)
CLUSTER BREAK-UP
STARCH LINES
PLANT CLEAN-UP
COOKING
RICE
FRYING
FLOUR
SHORTENING
DOUGH PREPARATION
MIXING
EGG
SEASONINGS
COMBINING
PACKAGING
FREEZING

FIGURE A-17

PLANT W

CHINESE SPECIALTIES PLANT

SIMPLIFIED PROCESS FLOW DIAGRAM
(heavy arrows designate major
wastewater generating operations)

- **Productivity Factors**

Based upon average daily wastewater volume, wastewater quality characteristics, and production data supplied by the plant, the following productivity factors were calculated.

Productivity Factors
Combined Process and Clean-Up Wastewaters

Constituent	Average kg/kkg Finished Product
COD	12
BOD	6.7
SS	4.0
VSS	3.8
Total P	0.041
TKN	0.27
Grease and Oil	4.7
Wastewater Generation (l/kkg finished product)	18,000

1 lb/ton = 0.5 kg/kkg
1 gallon/ton = 4.173 l/kkg

- **Pre-Treatment at the Food Plant**

Pre-treatment consists of screening and dissolved air flotation that is enhanced by alum coagulation. Caustic is also added for pH control.

The treated effluent is discharged to the municipal sewer.

MEXICAN FOODS

- Plant Code: X
- Location: West
- Category: 9
- Products: Mexican foods

Red taco sauce
Red taco sauce
Green taco sauce
Salsa brava
Salsa suprema
Salsa Victoria
Salsa ranchera
Chili chow chow
Red salsa jalapena
Green salsa jalapena
Guacamole dip mix
Tomatillo salsa
Hot chili mix
Cauliflower mix
Rajas de jalapenos
Jalapenos en esc.
Jalapenos en esc.
Jalapenos supremos
Yellow chilis mex. style
Pickled yellow chilis
Pickled yellow chilis
Pickled yellow chilis
Marinated cactus
Nopalitos tiernos
Nopalitos tiernos
Shredded shrimp, dry

- Significant Ingredients (used during sampling period)

Processed at Plant	Pre-Processed Elsewhere	
Beans	Tomatoes	Spices
Cactus	Beef	Chilis
	Shrimp	

A simplified schematic diagram of plant operations is shown in Figure A-18.

- Sampling Procedure

An automatic sampler was used to take eight samples during the processing shift, and two samples during the clean-up shift. The samples were taken at the inlet of No. 1 clarifier of the plant treatment facility.

- Wastewater Characteristics

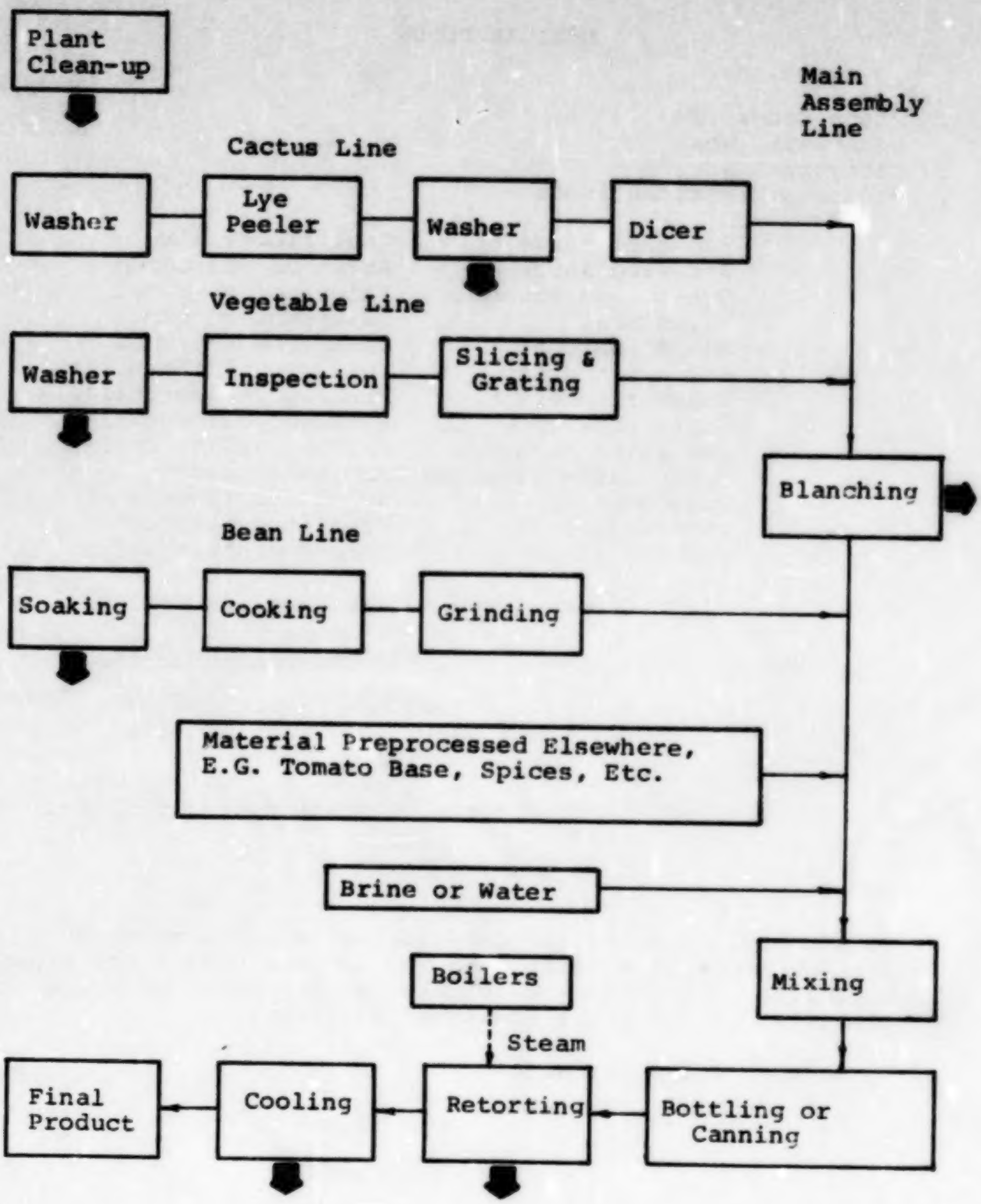

Plant Clean-up
Main Assembly Line
Cactus Line
Washer
Lye Peeler
Washer
Dicer
Vegetable Line
Washer
Inspection
Slicing & Grating
Blanching
Bean Line
Soaking
Cooking
Grinding
Material Preprocessed Elsewhere, E.G. Tomato Base, Spices, Etc.
Brine or Water
Mixing
Boilers
Steam
Final Product
Cooling
Retorting
Bottling or Canning

FIGURE A-18

PLANT X

MEXICAN FOODS PLANT
SIMPLIFIED PROCESS FLOW DIAGRAM
(heavy arrows designate significant
wastewater generating operations)

Process Wastewater
(8 a.m. - 5 p.m.*)

	COD	BOD	pH	SS	VSS	Total P	TKN
Avg. Conc. (mg/l)	1,600	1,100		260	170	22	31
Range of Conc. (mg/l)	920- 2,500	690- 2,000	4.9- 8.3	72- 710	48- 320	0.60- 160	15- 71

*Eight samples

Clean-Up Wastewater
(5 p.m. - 11 p.m.*)

	COD	BOD	pH	SS	VSS	Total P	TKN
Avg. Conc. (mg/l)	340	220		80	63	60	3.6
Range of Conc. (mg/l)	260- 420	170- 280	7.4- 8.3	76- 84	58- 68	23- 97	2.2- 5.0

*Two samples

- Productivity Factors

  Based upon average volume of wastewater generated during processing and during clean-up operations, wastewater quality characteristics from lab analysis, and production figures provided by the plant, the following production factors were calculated for the process shift, the clean-up shift, and the total effluent.

Productivity Factors
kg/kkg Finished Product

	COD	BOD	SS	VSS	Total P	TKN	Wastewater Generation (l/kkg product)
Process	11	7.3	1.7	1.1	0.15	0.20	6,600
Clean-Up	0.78	0.51	0.18	0.14	0.14	0.0083	2,300
Total	12	7.8	1.9	1.2	0.29	0.21	8,900

1 gallon/ton = 4.173 l/kkg
1 lb/ton = 0.5 kg/kkg

- **Pre-Treatment Facilities**

  Pre-treatment consists of 3 gravity clarifiers for removal of suspended solids and floatables. The clarifiers are manually cleaned as required. A large percentage of the suspended solids and floatables are effectively removed for disposal as solid waste.

BREADED FROZEN PRODUCTS

- Plant Code: Y
- Location: Midwest
- Category: 10
- Products: Breaded onion rings, breaded mushrooms, breaded perch.

- Significant Ingredients (used during sampling period)

Processed at Plant	Pre-Processed Elsewhere
Onions (slicing and breading only)	Perch
	Flour
Mushrooms (slicing and breading only)	Eggs
	Seasoning

A simplified schematic diagram of plant operations is shown in Figure A-19.

- Sampling Procedure

An automatic sampler was used to collect eight 24 hour time interval composite samples of the raw plant wastewater, as well as two composite samples of just the clean-up wastewater. The samples were collected from the final effluent pipe.

- Wastewater Characteristics

Combined Process and Clean-Up Wastewaters
(24 Hour Composites*)

	COD	BOD	SS	VSS	Total P	TKN	Grease & Oil
Avg. Conc. (mg/l)	12,000	4,500	7,100	7,100	37	100	360
Range of Conc. (mg/l)	6,100- 19,000	2,700- 5,600	2,900- 9,900	2,900- 9,800	15- 55	70- 120	130- 760

*Eight samples
pH range; 4.6 - 6.5

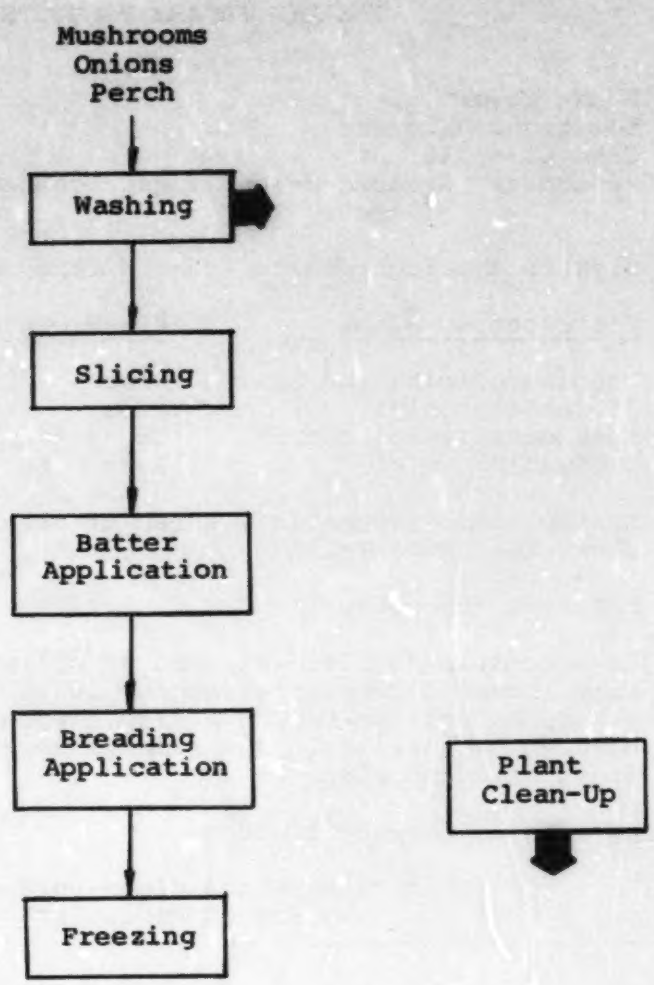

Mushrooms
Onions
Perch
Washing
Slicing
Batter Application
Breading Application
Freezing
Plant Clean-Up

FIGURE A-19

PLANT Y

BREADED ONION AND MUSHROOM PLANT
SIMPLIFIED PROCESS FLOW DIAGRAM

(heavy arrows designate major wastewater generating operations)

Clean-Up Wastewaters
(12 midnite-3:00 a.m.*)

	COD	BOD	SS	VSS	Total P	TKN	Grease & Oil
Avg. Conc. (mg/l)	11,000	3,500	8,000	7,800	63	110	170
Range of Conc. (mg/l)	10,600-12,000	3,400-3,600	7,500-8,500	7,400-8,500	63-63	110-110	150-190

*Two samples
pH range: 3.1 - 3.2

- Productivity Factors

Based upon average daily wastewater volume, wastewater quality characteristics, and raw ingredient consumption, data supplied by the plant, the following productivity factors were generated for the process shift, the clean-up shift, and the total effluent.

Productivity Factors
(kg/kkg Raw Product)

	COD	BOD	SS	VSS	Total P	TKN	Grease & Oil	WW[1]
Processing Shifts	19	8.4	8.0	8.0	0	0.12	0.90	1,400
Clean-Up Shift	21	6.6	15	15	0.12	0.21	0.32	1,900
Total Plant Operation	40	15	23	23	0.12	0.33	1.2	3,300

[1] Wastewater Generation in l/kkg raw product

1 lb/ton = 0.5 kg/kkg
1 gallon/ton = 4.173 l/kkg

- Pre-Treatment Facilities

No treatment is provided before discharge to the city sewer.

BREADED FISH AND SHELLFISH

- Plant Code: Z
- Location: West
- Category: 10
- Products: Frozen fish and shellfish (with and without breading).

  Shrimp, scallops, oysters, sole, perch, haddock, cod.

- Significant Ingredients (used during sampling period)

Processed at Plant

Shrimp (shell removal, cutting, breading)
Fish (cutting, breading only)
Scallops (breading)

Pre-Processed Elsewhere

Flour
Batter
Scallops
Shrimp (heads removed)

Sole
Haddock
Cod
(cleaned, deboned)

A simplified schematic diagram of plant operations is shown in Figure A-20.

- Sampling Procedure

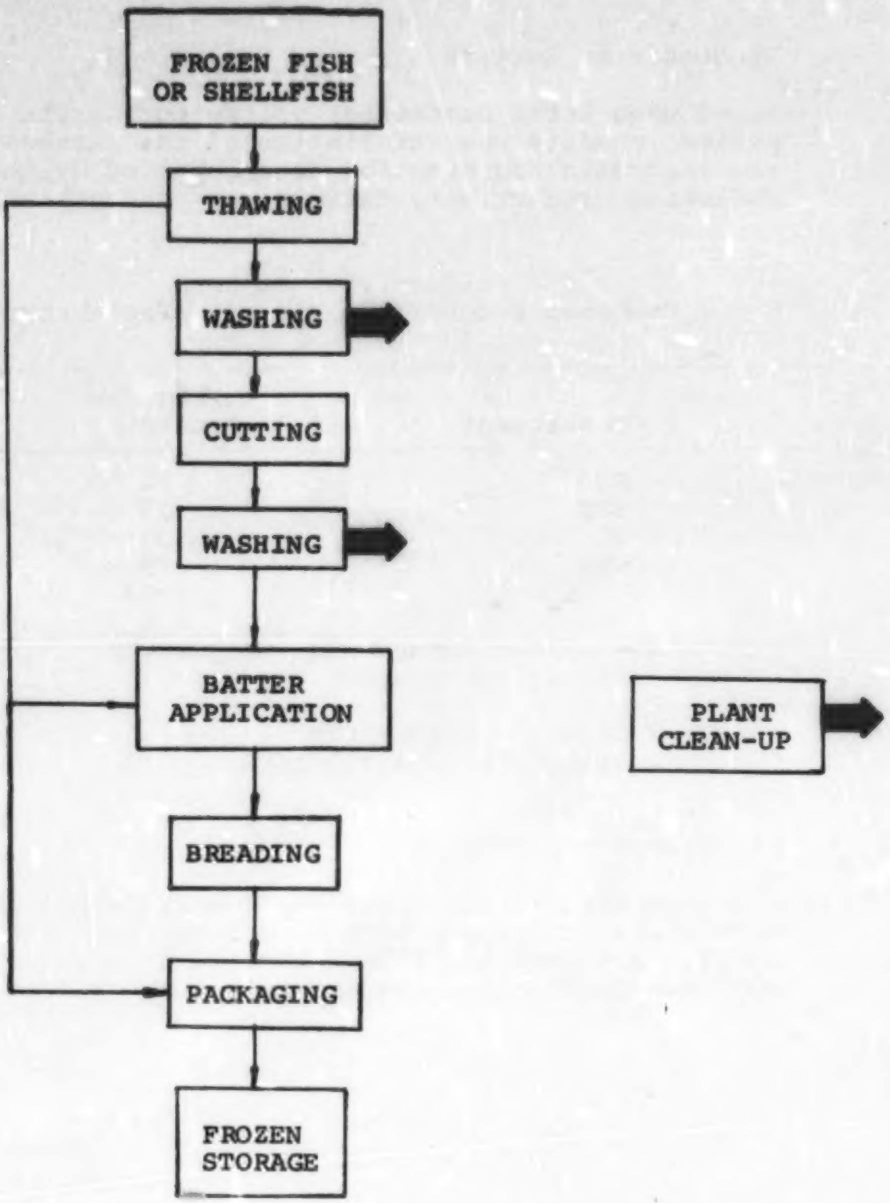
An automatic sampler was used to take eleven daily, time interval composite samples of the raw wastewater from the surge tank just prior to screening.

- Wastewater Characteristics

Combined Process and Clean-Up Wastewaters
(7 a.m. - 5 p.m.*)

	COD	BOD	Ph	SS	VSS	Total P	TKN
Avg. Conc. (mg/l)	720	400		330	320	6.3	52
Range of Conc. (mg/l)	270- 1,300	180- 600	7.1- 8.4	48- 730	44- 730	0.50- 12	21- 36

*Eleven samples



FROZEN FISH OR SHELLFISH
THAWING
WASHING
CUTTING
WASHING
BATTER APPLICATION
BREADING
PACKAGING
FROZEN STORAGE
PLANT CLEAN-UP

FIGURE A-20

PLANT Z

BREADED FISH AND SHELLFISH PLANT

SIMPLIFIED PROCESS FLOW DIAGRAM

(heavy arrows designate major wastewater generating operations)

- **Productivity Factors**

Based upon total wastewater volume during the sampling period, quality characteristics of the wastewater, and raw ingredient consumption data supplied by the plant, the following productivity factors were calculated.

Productivity Factors
Combined Process and Clean-Up Wastewaters
(7 a.m. - 5 p.m.)

Constituent	kg/kkg Raw Product
COD	66
BOD	37
SS	30
VSS	29
Total P	0.58
TKN	4.8
Wastewater Generation (l/kkg raw product)	92,000

1 lb/ton = 0.5 kg/kkg
1 gallon/ton = 4.173 l/kkg

- **Pretreatment Facilities**

Pre-treatment at this breaded fish and shellfish plant consists of vibratory screening prior to discharge to the sewer. However, the solids removed by the screen are also discharged to the sewer following grinding.

APPENDIX B

TYPICAL CALCULATIONS OF PLANT WASTEWATER PRODUCTIVITY FACTORS

Three similar methods of calculating productivity factors were used. They depended upon whether or not the plant provided daily figures on wastewater volumes and production tonnages, and whether samples of clean-up wastewater only were taken as well as samples of the total plant effluent.

Method I (used for plants A, D, E, F, K, P, Q, R, U, V, W, Z)

The most commonly used method of calculation was to correlate the average wastewater characteristics with average wastewater flow and production data for the sampling period. This method was used when daily wastewater volume and/or daily production data was not available. Samples taken were 24 hour composite samples of the total plant effluent.

Sample calculation:

Assume:

average daily wastewater flow = 100,000 gallons
average daily production = 200 tons
average COD concentration from ten 24-hour composite samples = 5,000 mg/l

Calculation:

wastewater generation = (100,000 gal/200 tons) x 4.173*
= 2,086 (l/kkg product)
productivity factor = $(5,000/10^6)$ x 2,086 l/kkg
= 10.4 (kg COD/kkg product)

Method II (used for plants J, N, X, Y)

This method is identical to Method I except that separate samples of clean-up water were taken along with total plant effluent or process shift samples. Average daily clean-up wastewater volume and total effluent or process shift wastewater volumes were available along with average daily production data.

Sample calculation:

---

*1 gal/ton = 4.173 l/kkg

Assume:

average daily clean-up wastewater flow = 25,000 gal
average daily process shift wastewater flow = 50,000 gal
average daily production = 50 tons
average clean-up wastewater COD concentration = 3,000 mg/l
average process shift wastewater COD concentration = 1,000 mg/l

Calculations:

clean-up wastewater generation = (25,000 gal/50 tons) x 4.173*
= 2,086 l/kkg
process shift wastewater gen. = (50,000 gal/50 tons) x 4.173
= 4,173 l/kkg
total wastewater generation = 2,086 + 4,173 = 6,259 l/kkg
clean-up shift COD productivity factor = (3,000/10^6) x 2,086 l/kkg
= 6.3 kg/kkg product
process shift COD productivity factor = (1,000/10^6) x 4,173 l/kkg
= 4.2 kg/kkg product
total COD productivity factor = 10.5 kg COD/kkg product

Method III (used for plants C, G, I, L, M, O, S)

This method is based upon daily wastewater volume and production information supplied by the plant. From this data, specific productivity factors and wastewater generation values for each sampling day can be calculated. Then, for example, all the individual daily COD productivity factors can be used to obtain an overall average and a range. Most samples were 24 hour composite of the total plant effluent.

Sample calculation: (2 days only - most plant were sampled 8 to 10 days)

Assume:

	10/9/74		10/10/74
wastewater flow	= 30,000 gal	wastewater flow	= 25,000 gal
production	= 15 tons	production	= 18 tons
COD concen.	= 1,200 mg/l	COD concen.	= 1,300 mg/l

---

*Note: 1 gal/ton = 4.173 l/kkg

COD productivity factor =

$$\frac{1,200}{10^6} \times 8,346 \text{ l/kkg}$$

= 10.0 kg/kkg

COD production factor =

$$\frac{1,300}{10^6} \times 5,796 \text{ l/kkg}$$

= 7.5 kg/kkg

Results	Average	Range
COD (kg/kkg product)	8.7	7.5-10.0
Wastewater Generation (l/kkg product)	7,070	5,800-8,350

Miscellaneous

- Plant B

  The technique used to calculate wastewater generation and productivity factors was a combination of Methods II and III. Daily information was available for both clean-up and processing shifts. However, in this case significant production occurred during the "clean-up" shift and therefore this shift was treated as a second processing shift. Productivity factors were calculated using tonnages produced during each processing shift only rather than over the whole day as was done with the other plants.

- Plant T

  Method II was expanded to four different waste streams rather than just "process" shift and "clean-up" shift. Separate samples of the total plant effluent, rice operation wastewater, and rice treatment plant effluent were taken as well as flow data for each stream. Productivity factors for each of these streams were used to calculate similar factors for the category "all plant operations except the rice production."